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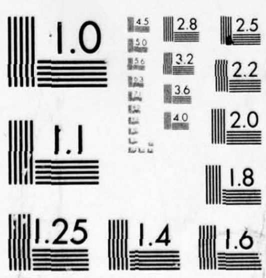

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SAINT SIMULATION OF A REMOTELY PILOTED VEHICLE/DRONE CONTROL FACILITY: MODEL DEVELOPMENT AND ANALYSIS

PRITSKER & ASSOCIATES, INC.
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AERŌSPACE MEDICAL RESEARCH LABORATORY

JUNE 1976

AEROSPACE MEDICAL RESEARCH LABORATORY
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AMRL-TR-75-118

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FOR THE COMMANDER

CHARLES BATES, JR.
Chief
Human Engineering Division
Aerospace Medical Research Laboratory

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A model of a real-time simulation of a Remotely Piloted Vehicle/Drone Control Facility (RPV/DCF) has been constructed using SAINT, a totally digital man-machine modeling and simulation technique. The real-time simulation consists of a mock-up of a DCF, where actual operators control the flight of simulated RPVs through the use of cathode ray tube (CRT) displays of RPV flight paths and parameters. The SAINT model consists of two interacting components. The state variable (other side)

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component of the model duplicates the simulation of RPV flight of the real-time simulation. The task-oriented component represents the control and decision tasks performed by the DCF operators. The interactions between the components include models of the presentation of mission status information to the operators and the processing of commands sent to the RPVs by the operators.

Through input values, the generalized SAINT model is made specific to one group of operators performing one mission of the real-time simulation. This mission is simulated using SAINT. The simulation results are evaluated by comparing them with the mission performance output obtained from the real-time simulation. By obtaining results that are statistically indistinguishable from the real-time simulation, the SAINT model demonstrates the applicability of the SAINT technique for the study of RPV/DCF and other complex man-machine systems. Recommendations are given for the expansion of the SAINT model of the RPV/DCF real-time simulation.

SUMMARY

This report describes the development and analysis of a SAINT model of a real-time simulation of a Remotely Piloted Vehicle/Drone Control Facility (RPV/DCF). The major component of the real-time simulation is a mock-up of a DCF in which operators monitor and control the flight of simulated RPVs through the use of cathode ray tube (CRT) displays of RPV flight paths and parameters.

In this research effort, a general purpose digital computer was used to model the real-time simulation. The modeling vehicle used was the previously developed digital computer program called SAINT. SAINT, Systems Analysis of Integrated Networks of Tasks, is a man-machine modeling and simulation technique through which the transformation from a real-time to a digital simulation can be accomplished. SAINT provides the simulation concepts necessary to model systems that contain both tasks (discrete elements) and state variables (continuous elements). The SAINT model presented in this report includes both of these elements as well as interactions between the elements. The state variable portion of the model duplicates the simulation of RPV flight of the real-time simulation. The task-oriented portion represents the control and decision tasks performed by the DCF operators. The interactions between the elements include the presentation of mission status information to the operators and the processing of commands sent to the RPVs by the operators.

The SAINT model of the RPV/DCF is developed to be applicable for all operator groups and all missions performed. The SAINT model simulates a specific mission through the insertion of input values that describe the mission.

The validity of the SAINT model of the RPV/DCF was evaluated by comparing mission performance outputs of the SAINT and real-time simulations. This procedure has resulted in a SAINT model of the RPV/DCF real-time simulation that is valid for one team and one mission and which demonstrates the applicability of the SAINT technique for the study of RPV/DCF and other complex man-machine systems.

This report describes the RPV/DCF real-time simulation, the SAINT model of the system, the model evaluation procedures, and the results of the validation process. The results are presented in tabular and histogram form. In addition, this report outlines procedures for using the SAINT model in

conjunction with the real-time simulation to efficiently analyze RPV/DCF system design. Procedures for expanding the SAINT model are also described.

PREFACE

This study was initiated by the Human Engineering Division, Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio 45433. The research was conducted by Pritsker & Associates, Inc., 1710 South Street, Lafayette, Indiana 47904. The work was performed in support of Project 7184 "Human Engineering for Air Systems," task 718413 "Man-Machine Models for System Performance Assessments." The research sponsored by this contract was performed between August, 1974, and September, 1975, under Air Force contract F33615-75-C-5012.

The authors are grateful to Mr. Robert G. Mills, Mr. Gerald P. Chubb, and Mr. Robert F. Bachert of the Aerospace Medical Research Laboratory and Dr. A. Alan B. Pritsker of Pritsker & Associates, Inc., for their assistance in the development of the SAINT simulation model of the RPV/DCF.

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SECTION I

INTRODUCTION

During the past several years, a tool has been developed to assist in the design and analysis of complex man-machine systems by providing a general framework within which a wide variety of systems can be modeled. SAINT, Systems Analysis of Integrated Networks of Tasks, provides the simulation concepts necessary to model the man and the machine in the face of environmental factors (1,2,3,4,5,6).

Independent of this effort has been the development of a real-time computer simulation of a multi-operator Remotely Piloted Vehicle/Drone Control Facility (RPV/DCF). This real-time simulation is currently being used to evaluate operator and system parameters relevant to RPV design and performance. The major component of the system is a mock-up of a DCF, where actual operators control the flight of simulated RPVs through the use of CRT displays of RPV flight paths and parameters.

This report, along with a companion report (9), documents the development and analysis of a SAINT computer simulation model of the real-time RPV/DCF simulation.

Objectives of the SAINT Modeling Effort

The SAINT model is constructed to duplicate the RPV/DCF real-time simulation and to output measures of system performance that can be used to study RPV system design. Since this is the initial phase of the SAINT RPV/DCF modeling effort, the objectives of this effort are to demonstrate the applicability of the SAINT modeling technique to the analysis of the RPV system and to indicate how future efforts should be constructed and coordinated with the real-time simulation so that an effective analysis of RPV system design and operator requirements can be obtained.

The SAINT model of the RPV/DCF real-time simulation is the first major application of the revised SAINT simulation language (SAINT III). Thus, another objective of this effort is to verify the operation of the SAINT simulation program. Also, since the RPV/DCF simulation is a highly complex man-machine system, the SAINT RPV/DCF model will establish SAINT as an effective technique in the analysis of complex systems.

Scope of the SAINT Modeling Effort

The RPV/DCF real-time simulation referred to as "RPV II" is modeled in SAINT for this contract. The mission structure of RPV II is explained in Section II of this report. However, since this is the initial modeling effort of the RPV/DCF simulation in SAINT, the evaluation procedure will be performed for only one team and one mission of the real-time simulation study. The continuation of this effort beyond this contract should include the analyses of additional missions, operator teams, and system configurations.

Report Structure

This report describes the development and analysis of the SAINT model of the RPV/DCF simulation. The technical documentation of the SAINT model is contained in a companion report (AMRL-TR-75-119). Section II describes the real-time RPV/DCF simulation including the computer simulation of RPV flight, the CRT console display and keyboard, and the operators' responsibilities and performance. The information detailed in this section was obtained from extensive discussions with AMRL personnel responsible for the facility, through interviews with the operators, from observations of the simulation in operation, through actual experience at the CRT consoles, and from reference material (7,8).

Section III presents the SAINT model of the RPV/DCF real-time simulation described in Section II.

Section IV defines the model evaluation procedure. It includes the performance variables considered, the validation procedures applied, and the results of the analysis.

Section V presents the conclusions, and Section VI makes recommendations concerning the use and embellishment of the SAINT model of the RPV/DCF simulation.

SECTION II

THE RPV/DCF REAL TIME SIMULATION

The Remotely Piloted Vehicle/Drone Control Facility (RPV/DCF) system model developed at the Aerospace Medical Research Laboratory (AMRL) is designed to simulate, in a real-time environment, a mission consisting of multiple groups of RPVs flying to a target and returning to home base (7,8). RPVs are launched on a mission in groups of three: a strike (S) RPV carrying payload, an electronic (E) RPV carrying jamming equipment, and a reconnaissance (L) RPV carrying film recording equipment. The flight of these RPVs is coordinated so that the S and E RPVs arrive at the target together followed by the L RPV. The E RPV causes electronic disturbances in the enemy's defense communications, weapon control mechanisms, or radar sensors to protect the S RPV, while the L RPV photographs the target after the strike for purposes of damage assessment. Up to eleven groups of RPVs may take part in a single mission, with an additional L RPV following the groups taking wide area photographs of the entire target area.

The real-time RPV/DCF simulation consists of two components. The first is a computer simulation of RPV flight which monitors and computes the status of each RPV during the entire mission. In this simulation, RPV flight is affected by errors in onboard navigation and position reporting systems, by enemy electronic interference and defenses, and by equipment malfunctions. Due to these considerations, RPVs may be lost or may fly off course, and thus require external monitoring and control. The second component of the real-time system, the DCF operators, provide that control.

The digital simulation program updates the status of each RPV every five seconds and supplies this information to the operators through CRT displays. This status information consists of estimated times of arrival (ETAs), flight paths, velocities, altitudes, fuel levels, target coordinates, etc. The DCF operators utilize this information to control the progress of the mission. To correct the RPV flight errors and to perform their other mission duties, the DCF operators send commands via the CRT consoles to the simulated RPVs. A light pen and CRT terminal keyboard are used to generate the commands. Thus, RPV flight is simulated by a digital computer which accepts changes in RPV flight parameters that are input to the CRT consoles by the operators.

Simulation of RPV Flight

At launch, each RPV is assigned a flight path which is assumed to be optimal in terms of terrain and defense avoidance. This flight path is an input to the mission. The geographic area over which the RPVs fly and two typical paths are shown in Figure 1. Each flight path is divided into three phases. The enroute phase includes the RPVs launch from a launch site in the safe zone - that area below the Forward Enemy Battle Area (FEBA) line - and the flight to the target area; the terminal phase involves RPV flight within the target area; and the return phase refers to the flight of the RPV from the target area to the recovery area in the safe zone. The flight paths for the RPVs are stored onboard each RPV in computers that control RPV flight during the enroute and return phases. During the terminal phase, S RPVs are controlled by a pilot at the DCF via a TV camera in the nose of the RPV. The real-time simulation employs a television camera - terrain board installation during this phase of terminal flight. RPVs that are not flown in this manner (E and L RPVs) through the terminal phase are flown by pseudo-pilots which are controlled by the RPV flight simulation program and fly the RPVs according to onboard flight path instructions.

In addition to a flight path, each RPV has a flight profile that indicates the altitudes and velocities that the RPV should fly during different phases of the mission. All RPVs are designed to fly at an altitude of 200 feet during enroute, to "pop-up" to 3000 feet for the terminal phase, and then to "pop-down" to 200 feet during return. The altitude of the RPVs for enroute and return is set low (200 feet) to avoid detection and destruction by enemy defenses. The velocity profiles for the RPVs depend on RPV type. E and L RPVs are designed to fly the entire mission at 400 knots. S RPVs are designed to fly the enroute and return legs at 400 knots and the terminal phase of the mission at 250 knots. However, the three types of RPVs should be coordinated so that they reach the target area together, while recoveries should be separated in time. Thus, changes are made to RPV velocity so that the RPV reaches the target and recovery areas at required times. For purposes of the real-time simulation, velocity and altitude changes are considered instantaneous. Navigation system errors affecting altitude are assumed negligible.

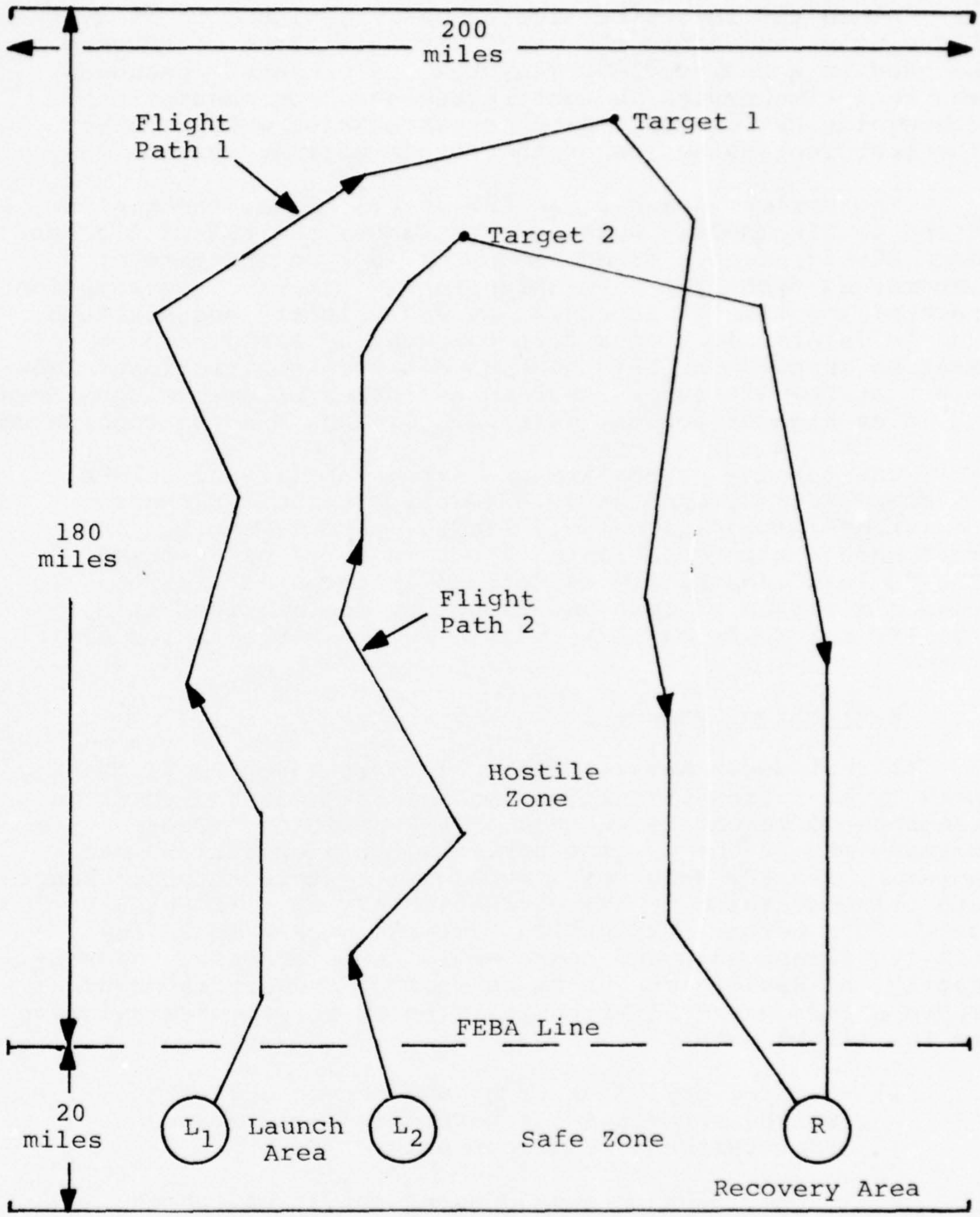


Figure 1. Geographical Area for RPV Flight.

RPV Characteristics

Since the real-time simulation is designed to study the RPV system, and since the exact specifications of RPVs to be used in a real-world RPV system are presently unknown, the real-time system is constructed based on assumptions concerning RPV design and performance which appear to be the best representation of the future working system.

The maximum speed of an RPV is 475 knots; the minimum speed is 250 knots. Outside this range, the RPV will crash. Each RPV is given a fixed amount of fuel at the time of launch; as specified on mission input. The fuel consumption rate of the RPVs is dependent on RPV velocity and altitude and is determined from a fuel consumption table read on mission input. The RPVs have no altitude restrictions. However, at low altitudes, terrain avoidance becomes a consideration; while at high altitudes, defense avoidance must be considered.

The turning capability or maneuverability of an RPV is completely defined given a specific set of RPV characteristics (wingspan, weight, length, thrust, etc.). In most cases, this capability is put in terms of "g-load". The "g-load" capability is defined in terms of minimum possible radius of turn and is set at one nautical mile. All RPV turns are made at the minimum possible radius of turn.

Navigation Systems

A real-world RPV will attempt to achieve its flight path by adjusting its flight control surfaces and speed in response to momentary changes in RPV position. These changes may be due to wind currents, turn execution, etc. However, the RPV requires a mechanism to detect these changes and this mechanism is the navigation system. If the RPVs were given perfect navigation systems, no RPV would fly off its flight path and there would be no errors. Unfortunately, no navigation system is perfect and errors occur. These errors are manifested in three principal ways relative to the flight path:

1) lateral deviation or ground course deviation, which represents the perpendicular distance from the desired flight path;

2) along track or ground speed deviation, which represents the distance ahead or behind the desired flight path position that the true position lies; and

3) expected time of arrival (ETA) deviation, which represents the time differential between the flight path ETA and the actual times of arrival at some specific geographic point.

These errors are illustrated in Figure 2.

There are many types of navigation systems, each with a different expected accuracy. The real-time simulation considers only dead reckoning navigation systems; navigation systems that cannot measure position. They have knowledge of only two quantities: the time of day and an estimated ground speed vector. This vector is composed of a ground course (GC) estimate and a ground speed (GS) estimate. An RPV with one of these navigation systems will assume that the estimated ground speed vector is accurate (which it will not be) and act accordingly, thus causing flight error. This error will accumulate if not corrected by an outside force, since the RPV will not realize that there is any error at all. Three types of dead reckoning systems are simulated: basic, doppler, and inertial. Each RPV starts the mission with the inertial navigation system operative and the basic and doppler systems as back-up. The errors of the GC and GS estimates made by the navigation systems are normally distributed and the parameters of these errors for each RPV are read on mission input.

Communication Links

For the DCF to be aware of RPV status and for the RPV to receive commands from the DCF, there must be communication between the RPV and DCF. Since communication links operate on a straight line basis, a relay aircraft must be used to overcome the interference effects of high terrain and the curvature of the earth. The three data links modeled in this simulation are illustrated in Figure 3. The command data link (CL) is used to transmit instructions to the RPV from the DCF and to confirm the reception of these instructions to the DCF from the RPV. The TV video data link (TV) is used to transmit television pictures from the nose of the RPV when it is over the target area. It is used only over the target area so that the RPV is as radio silent as possible during the other mission phases. The position reporting data link (PR) transmits radio signals from the RPV that are converted into RPV position reports at the DCF. Due to interference and imperfections in communications equipment, PR reports are never exact.

Position report errors arise from two conditions. First, the time required for a signal from the relay aircraft to reach the RPV and return to the relay aircraft is measured.

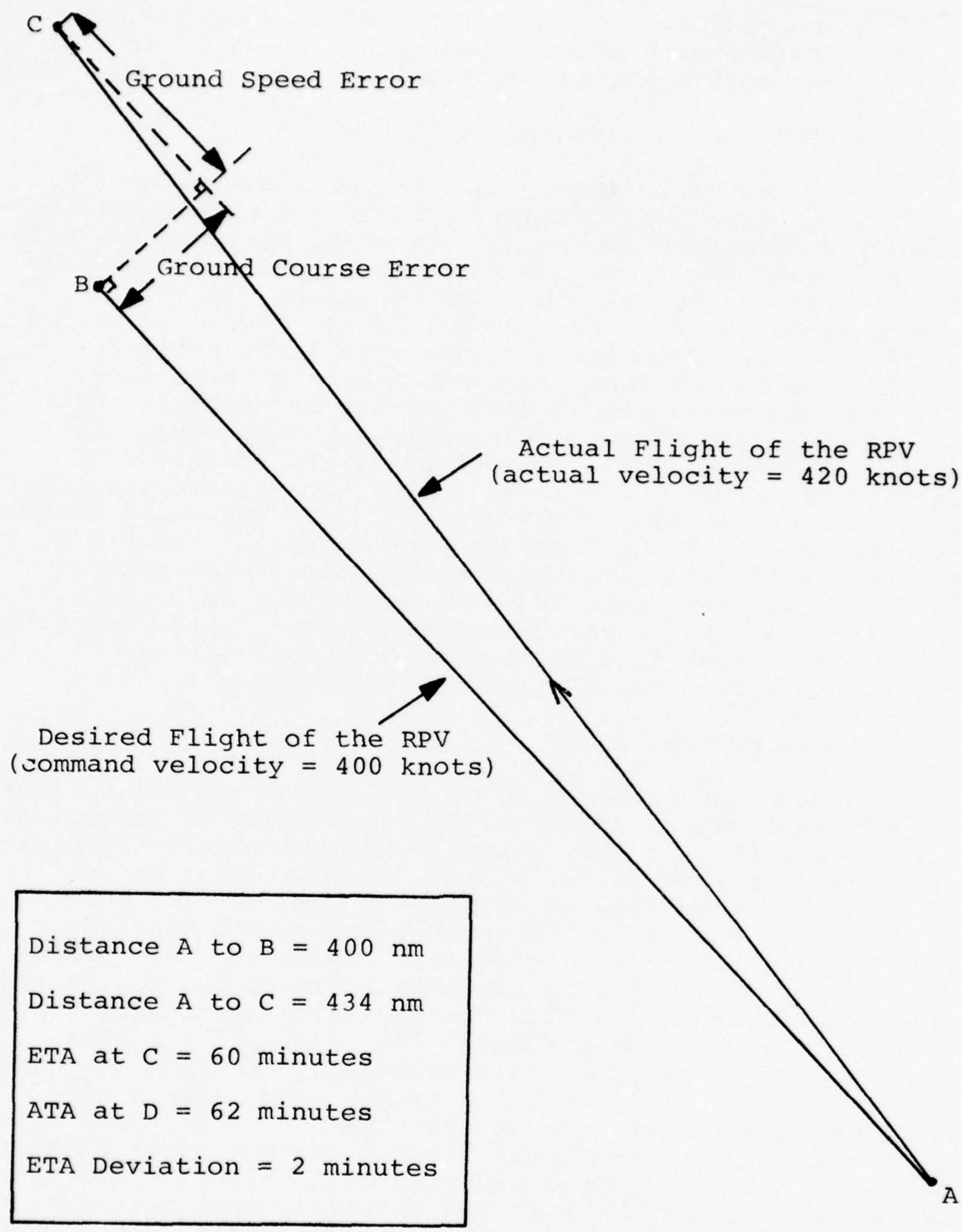


Figure 2. Navigation System Errors.

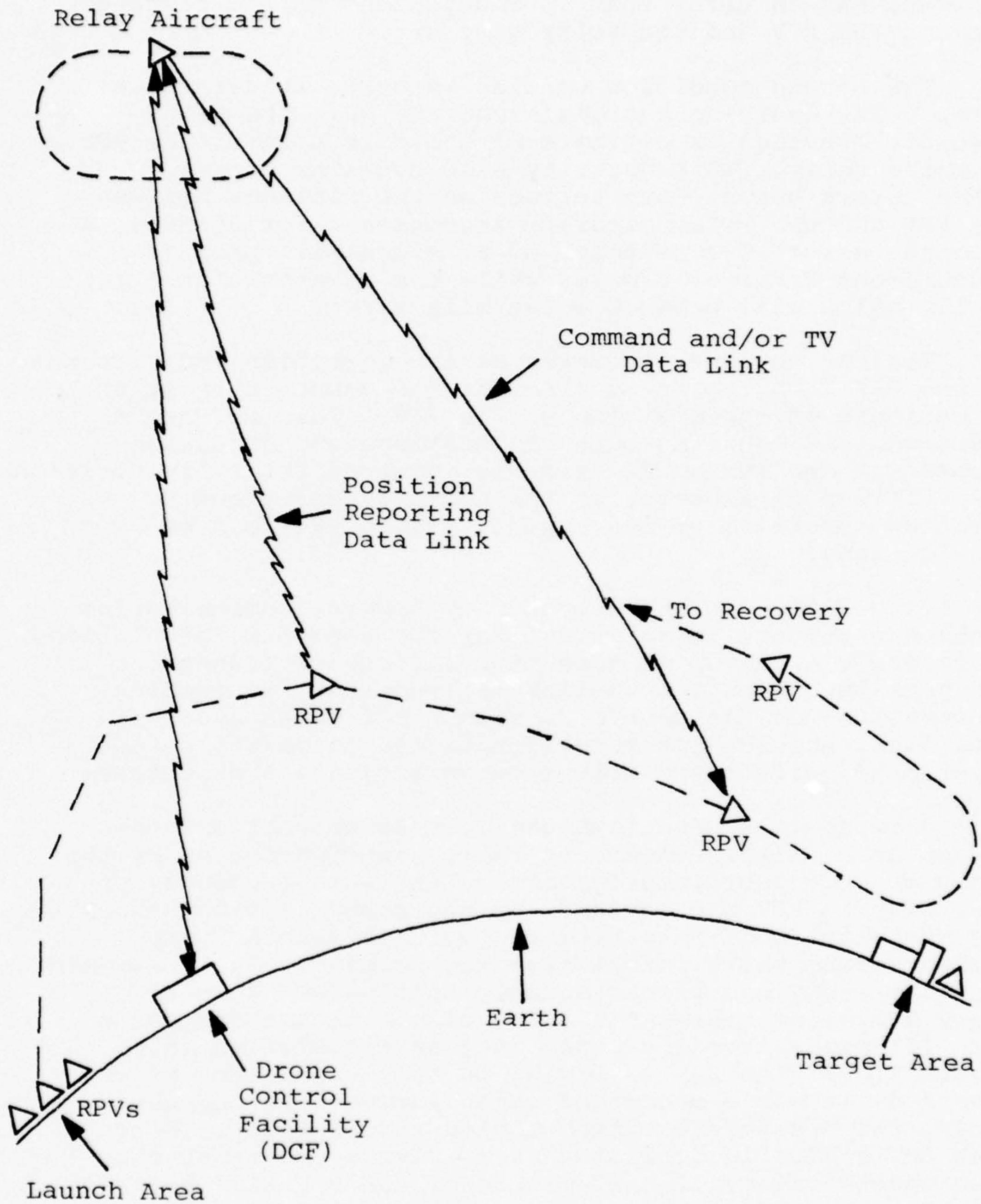


Figure 3. Pictoral Description of RPV Data Links.

The time value observed is used to estimate the distance between the RPV and the relay aircraft. This distance estimate has an error that is independent of the distance between the RPV and the relay aircraft.

The second condition causing PR error is directional error. In receiving a signal from the RPV, the relay aircraft provides an estimate of the direction of the RPV from the relay. This quantity also contains errors. These errors become more serious as the distance between the RPV and the relay aircraft increases. For example, a 1 degree error at a distance of 57 miles will produce a measurement error of 1 mile, while the same angular error at 114 miles will produce a two mile error.

The DCF obtains estimates of the direction and distance of the RPV from the relay aircraft and converts these to an estimate of the position of the RPV. This is the PR position, and contains both the distance and direction errors. A new random PR error is incurred for every position report. The parameters for the normally distributed position report range and angular errors are read on mission input.

In addition to the errors they impose, communication links are subject to failure. For the real-time simulation, there are two causes of data link failure: malfunctions and jamming. When a data link malfunctions, it remains inoperative for the entire mission. All three types of data links are subject to malfunctions. Jamming, on the other hand, will cause only a temporary data link outage.

Jamming is a condition that occurs only around the target area. It is caused by radio stations set up by the enemy to broadcast interference on the same frequency of the relay to RPV broadcasts. If the enemy is successful, the communication links between the relay and RPV are broken and no valid information can be sent. It is assumed that the enemy has placed a radio station or "jammer" every 2.5 miles across the front of the target area on a line 165 miles from the FEBA line, as illustrated in Figure 4. If the RPV is flying in the shaded area of Figure 4, it has a chance of being jammed. In the white areas, the messages are transmitted successfully. (Note that RPV status is monitored every five seconds; at each five second interval, the positon of the RPV will be used with the probability of message error at that position to determine if the RPV is jammed. If it is, it will be jammed for five seconds.) The probability of an RPV being jammed when it is in the shaded area depends upon its

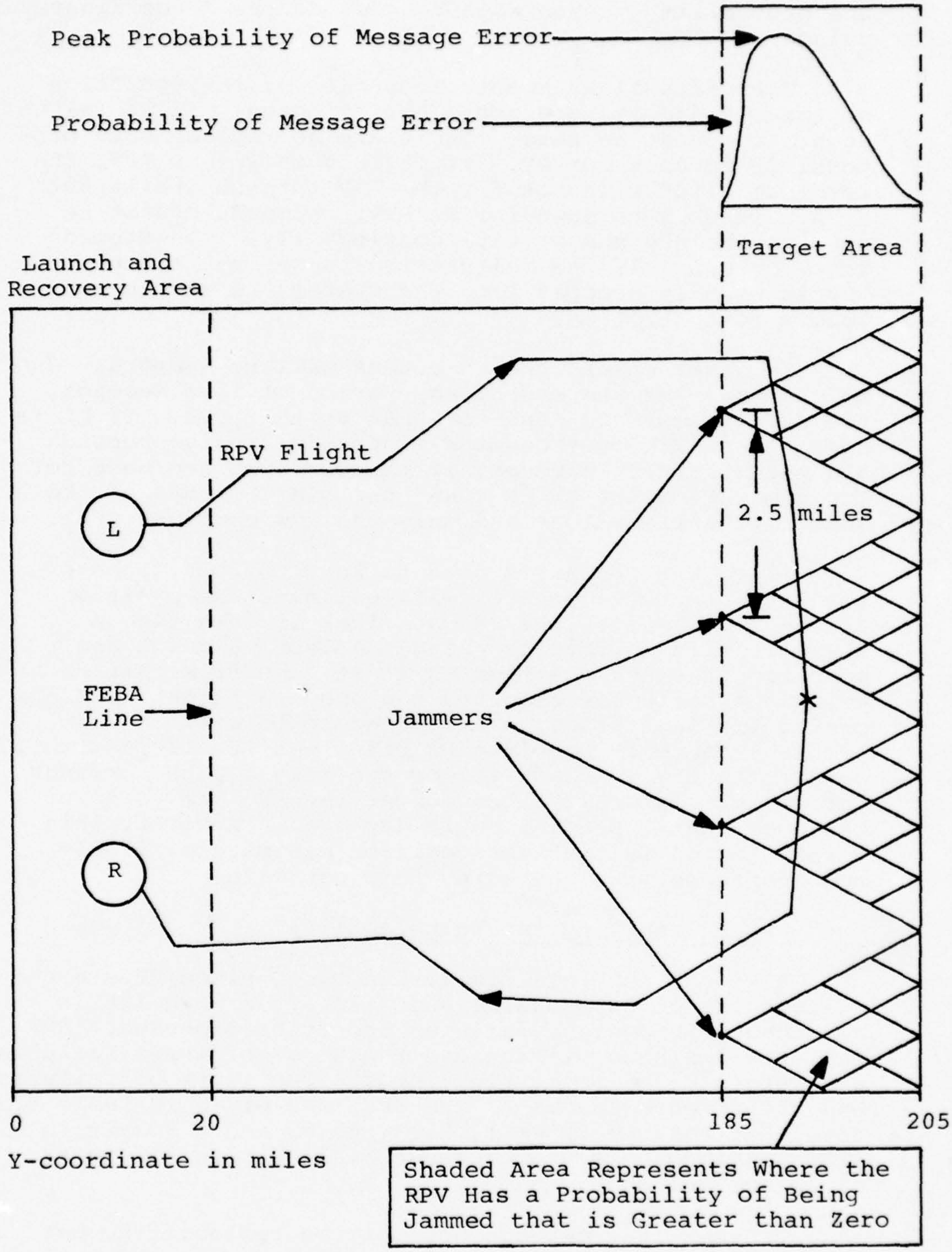


Figure 4. Jamming Model.

Y-coordinate. A table read on mission input provides the probability values with respect to the Y-coordinate values.

When data links become inoperative, the operation of the DCF and its operators are affected. If TV is down, it cannot be used. There are no replacements or possible repairs for TV. If it is down for an RPV, the terminal pilot will not fly the RPV through the target area. If CL goes down for an RPV, commands cannot be sent to the RPV and it will continue flying on stored instructions. If the malfunction is permanent, the RPV is usually dropped from the system, as it can no longer be controlled.

In other cases, the CL outage will be temporary due to jamming. At the end of any period of five seconds, the DCF attempts to send commands to the RPVs. If CL is down for an RPV, the command is saved for five seconds and then resent. However, if new commands are made for the same RPV while CL is down, the old commands of the same type will be lost and only the new commands sent.

Since the operators need to know the positions of the RPVs, the DCF computer will estimate the position of the RPV whenever the PR data link is down for an RPV. It will do this by using the last PR point and computing the RPV position as if it came from that PR point and perfectly executed the onboard flight commands during the last frame. This PR estimate will contain errors because 1) the last PR point was itself in error, and 2) the RPV will not follow the flight path commands perfectly. Naturally, the longer the PR link is down, the more the PR prediction is degraded. However, this extrapolation is the best position estimate available and operators must act using this estimate.

RPV Reliability and Vulnerability

RPVs are not infallible. In fact, since RPVs are designed to be inexpensive and pilot-free with little redundancy in design, failures are to be expected. RPV failures during a mission and the times of these failures are determined from mission input. The types of failures and their consequences to the RPVs are given in Table I. Note that failure types 1, 2, 3, 4, 5, and 6 result in RPVs leaving the system. These will be referred to as "terminal" malfunctions.

RPV survival depends not only on reliability, but also on altitude, deviation from flight path, and the

TABLE I

RPV FAILURES AND CONSEQUENCES

FAILURE TYPE	CONSEQUENCE TO RPV
1. Pitch	RPV will crash
2. Roll	RPV will crash
3. Altitude	RPV will crash
4. Generator	RPV will crash
5. Thrust	RPV will crash
6. Onboard Computer	RPV out of mission
7. Current Navigation System	RPV will fly off course until a new navigation system is put in operation by DCF
8. Communication Links	Links down for rest of mission

resources of the enemy. Taking all these factors into consideration, the probability of survival of an RPV has been made a function of altitude and lateral deviation for the simulation. These probabilities are given in terms of probability of survival for five seconds. Thus, every five seconds, the position of the RPV will be recorded and the survival probability of this RPV will be tested. A table of survival probabilities based on altitude and lateral deviation is given on mission input.

Operator Activities

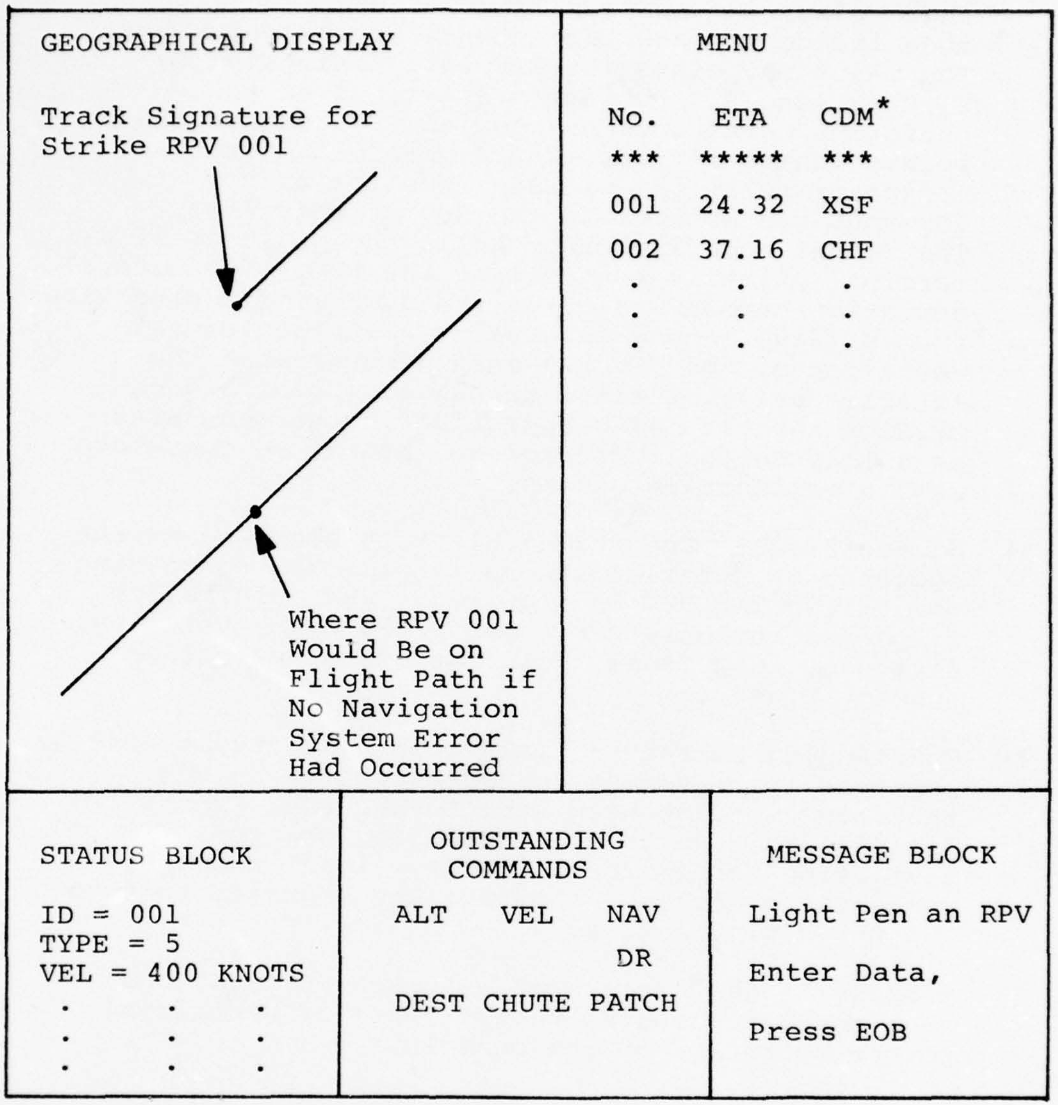
There are five persons stationed in the mock-up of the DCF. Four of them act as enroute/return operators and are seated at the CRT consoles. The fifth person acts as the terminal pilot, whose only responsibility is to fly S RPVs through the terminal phase of the mission using the TV camera-terrain board installation.

The information concerning operator activities presented below was obtained from extensive discussions with AMRL personnel responsible for the facility, through interviews with the operators, from observations of the simulation in operation, through actual experience at the CRT consoles, and from reference material (7, 8).

CRT Consoles and Functional Keyboards

DCF operators are informed of mission status through the CRT terminals in front of them. In addition, operators send commands to the RPVs and instructions to the terminals through a function keyboard. The CRT display, as pictured in Figure 5, contains five separate information blocks:

1) Geographical Display: This area displays a two dimensional view of RPV flight. The information that can be displayed for any or all RPVs includes flight paths, major waypoints, track signatures (reports of the position of the RPVs), and targets. This display has three scales (MOD 1, MOD 2, and MOD 3) which control the size of the display. MOD 1 makes the display 200 x 200 nm (nautical miles). This places the entire geographical area of the simulation in view. MOD 2 and MOD 3 cause the display to be 20 x 20 nm and 7 x 7 nm, respectively, centered about the position of the individual RPV that the operator is viewing. Thus, by controlling the geographical display, the DCF operator can monitor the entire mission or concentrate on the position of a single RPV.



* C - Command Link Status ("C" if up; "X" if down)

D - Waypoint Designator

M - RPV Flight Mode ("F" for flight plan follow; "C" for continuous control by the Terminal Pilot)

Figure 5. Sample CRT Display.

2) Menu Area: This area displays information about the status of all RPVs. It gives the RPV number, the next major waypoint of the RPV and the ETA to that point, the command link status, the flight mode indicator, and the lateral deviation number. The major waypoints for RPVs are designated by S, H, B, and R. Operators are required to perform special actions when an RPV reaches those points in its flight. The command link status indicator tells the operator whether or not commands can be sent to the RPV at this time. The flight mode indicator tells the operator if a terminal pilot is controlling the RPV. The lateral deviation number indicates the number of consecutive frames (five second intervals) that the lateral deviation of the RPV has been greater than the lateral deviation alarm threshold (specified on mission input). Also appearing in the menu area is a malfunction indicator to inform the operators when a malfunction occurs.

3) Status Block: The status block is accessed by the operator if detailed status information concerning one particular RPV is required. The information displayed includes RPV number, RPV type, velocity, altitude, fuel level, fuel rate, and navigation system in use.

4) Outstanding Commands: This area will display the commands initiated by the operator for an RPV that have not yet been sent to the RPV. These include altitude changes, velocity changes, navigation system changes, directional changes, requests to destruct the RPV, and requests to have the RPV deploy chutes.

5) Message Block: This area displays instructions from the DCF computer to the operator pertaining to the operation of the console.

The information displayed on the consoles is updated every five seconds, giving the operators information concerning mission status only at discrete five second intervals of time.

Operators send commands to the RPVs and instructions to the CRT terminals through the use of the functional keyboard, the terminal keyboard, and a light pen (LP) which recognizes positions on the CRT display. RPVs are selected from the menu by light penning the RPV number or geographical position of the RPV in the geographical display. The functional

keyboard is pictured in Figure 6. The types of commands the operators can make and the procedures for doing so are given in Tables II, III, and IV.

Operator Responsibility

Each enroute/return operator has a specific set of RPVs under his control during the enroute and return phases of the mission and another set for handover (giving RPV control to the terminal pilot or a pseudo-pilot) and handback (taking RPV control back from the terminal pilot or a pseudo-pilot) operations.

RPVs are launched and fly in groups of three. The arrival of these RPVs to their respective hand-off coordinates (the position where the terminal pilot or pseudo-pilot assumes control), called the H waypoint, must be synchronized by the operators. The E RPV must reach its H waypoint 15 seconds after the S RPV reaches its H waypoint, while the L RPV reaches its H waypoint 2 minutes after the S RPV reaches its H waypoint. The time allotted for each S RPV to reach its H waypoint is given to the operators as the mission begins. The ETAs for the associated E and L RPVs are computed from these values. In addition to the above requirements, S RPVs are given desired ETAs to recovery which operators must try to satisfy. The recovery of each S RPV and the other RPVs must be timed so that no two RPVs are recovered within 15 seconds of each other. Operators make RPV velocity changes in order to meet the mission ETA requirements.

In addition to the ETA requirements discussed above, operators are also required to keep each RPV as close to the desired flight path as possible for the duration of the mission. This is accomplished by applying a directional change, or patch, to the RPV when the RPV is observed by the operator as off course. The decision to patch is made based on the lateral deviation number displayed in the menu or on the actual lateral deviation obtained from the RPV status block.

In order to alter the path of an RPV, the operator indicates, on the geographical display, the points through which the RPV is to fly. The light pen is used in conjunction with a MOD display to generate the new coordinates. The specified points will normally be located between the present position of the RPV and the original flight path. The last point specified is the reconnect point, and is located on the original flight path. An example of acceptable and unacceptable patch points is shown in Figure 7.

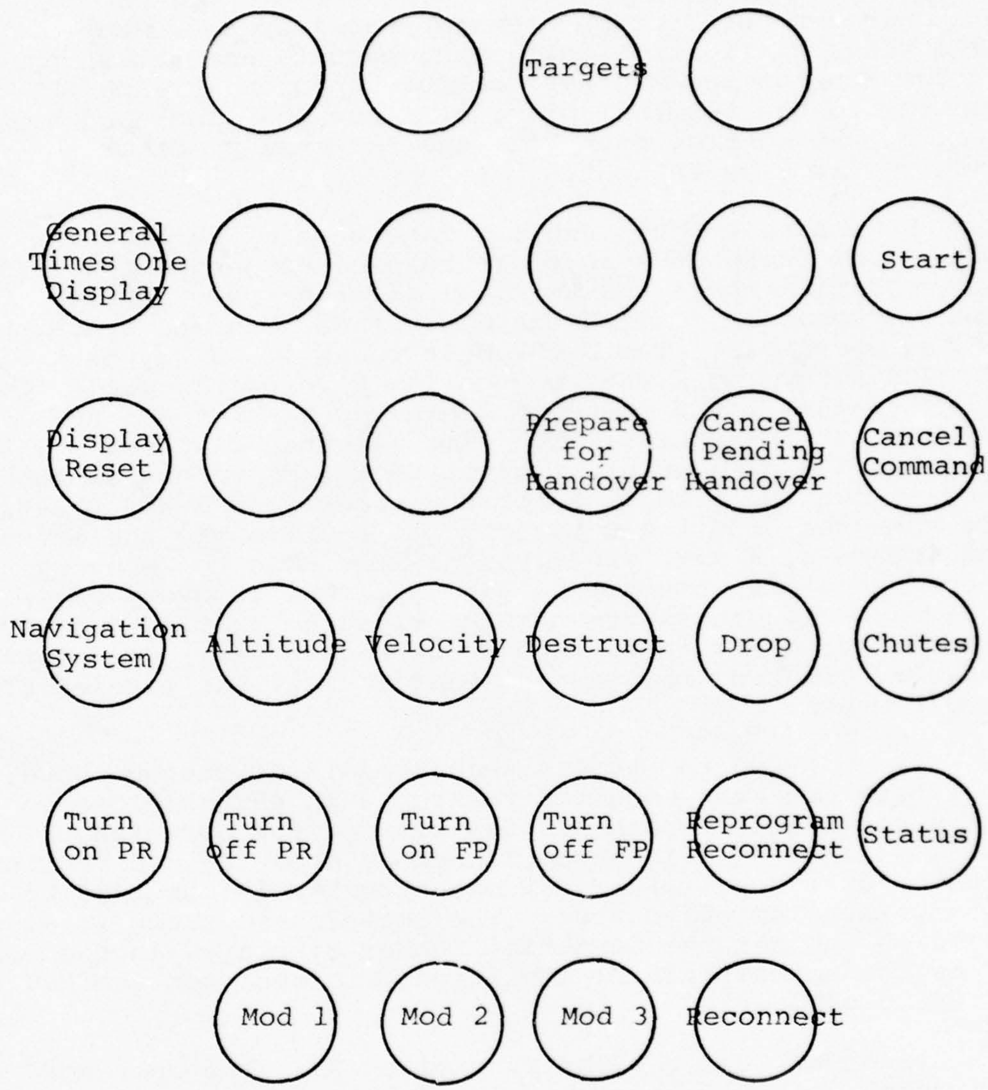


Figure 6. Functional Keyboard.

TABLE II

INSTRUCTIONS INITIATED USING ONLY THE FUNCTIONAL KEYBOARD

BUTTON PUSHED	INSTRUCTION
Targets	Display the targets or reset and do not display the targets if they are already displayed.
General Times One Display	Display the whole geographic area in its normal scale (200x200 miles).
Display Reset	Blank the RPV status block.
Start	Start the simulation.
Cancel Pending Handover	Cancel the handover just requested.

TABLE III

INSTRUCTIONS INITIATED USING KEYBOARD BUTTON AND LIGHT PENNING THE APPROPRIATE RPV

BUTTON PUSHED	INSTRUCTION
Turn on PR	Display the position report track signature of the light penned RPV.
Turn off PR	Turn off the display of the position report track signature of the light penned RPV.
Turn on FP	Display the flight path for the light penned RPV.
Turn off FP	Turn off the display of the flight path for the light penned RPV.
Status	Display the RPV status block for the light penned RPV.
MOD 1	Display the normal 200x200 nm area and prepare for patching to the light penned RPV.
MOD 2	Display the 20x20 nm area around the light penned RPV and prepare for patching to this RPV.
MOD 3	Display the 7x7 nm area around the light penned RPV and prepare for patching to this RPV.

TABLE IV

COMMANDS SENT TO RPVs AND PROCEDURES FOR THEIR INITIATION

COMMAND DESIRED	PROCEDURE ("PRESS" REFERS TO A FUNCTIONAL KEYBOARD BUTTON; "TYPE" REFERS TO THE CONSOLE KEYBOARD)
Prepare an RPV for Handover	Press "Prepare for Handover", type in the pilot or pseudo-pilot number to be handed to, type "EOB", light pen the appropriate RPV.
Cancel the last command requested for an RPV	Press "Cancel Command" and light pen the RPV.
Change the Navigation System of an RPV	Press "Navigation System", light pen the RPV, type in the new navigation system code, type "EOB".
Change the Altitude of an RPV	Press "Altitude", light pen the RPV, type in the new altitude, and type "EOB".
Change the Velocity of an RPV	Press "Velocity", light pen the RPV, type in the new velocity, and type "EOB".
Destruct an RPV from the system	Press "Destruct" and light pen the RPV.
Drop an RPV from the system	Press "Drop" and light pen the RPV.
Cause an RPV to deploy its chutes	Press "Chutes" and light pen the RPV.
Put a directional patch on an RPV	Press a "MOD" button, wait until the console display has presented the MOD display requested, light pen the points the RPV is to fly through, press "Reconnect", and light pen the point where the RPV is to be back on the flight path.
Reprogram an RPV	Same as above except press "Reprogram Reconnect" instead of "Reconnect".

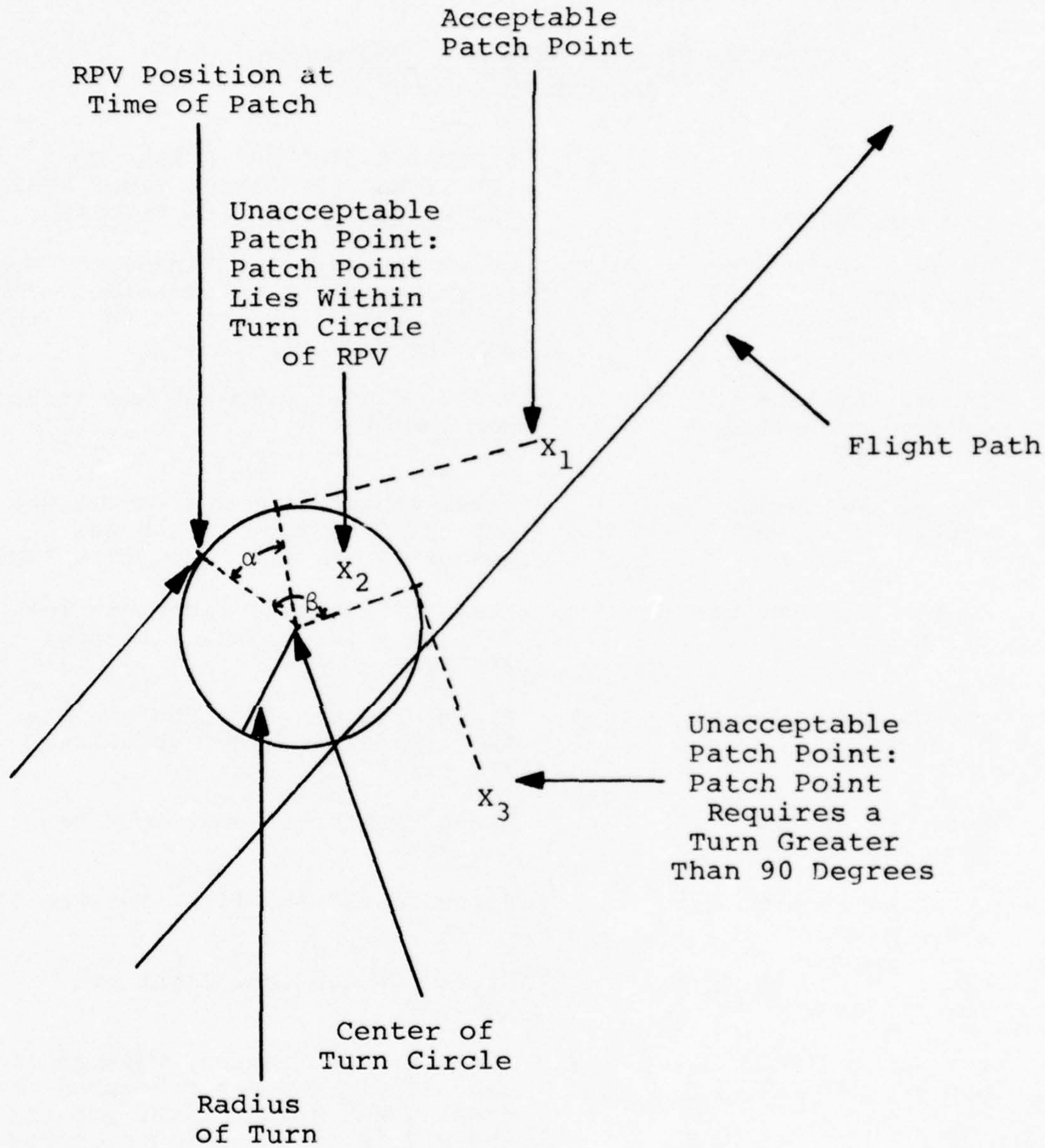


Figure 7. Example of Acceptable and Unacceptable Patch Points.

The patch point designated as X_1 can be reached by the RPV from its present position and heading by turning α degrees to the right at its minimum radius of turn and then flying straight to the point. This is an acceptable patch point. The patch point X_2 is not acceptable, as it lies within the minimum turn radius of the RPV. The patch point X_3 is also unacceptable, as it requires a turn of more than 90 degrees (β). Before an operator can successfully alter the flight path of the RPV, he must specify acceptable patch points to the DCF computer. If he does not, the patch will be rejected and the RPV will continue to fly on its present course.

The number of turns actually made by an RPV during a patch is one greater than the number of patch points specified, as a roll-out turn is required to achieve the specified heading at the reconnect point. In addition, all turns are made at the minimum radius of turn to ensure that the RPV flies the shortest possible distance.

Another duty of the operator involves the activities in preparation for and as a result of the RPV being in the target area. It includes the pop-up maneuver, where the velocity and altitude of the RPV are changed for the approach to the target; the handoff activities, where control of the RPV is given to the terminal pilot or pseudo-pilot; the handback activities, where control of the RPV is released by the terminal pilot or the pseudo-pilot; and the pop-down maneuver, where the altitude of the RPV is changed for the return phase. To explain these activities, Figure 8 gives typical flight paths around the target area for S, E, and L RPVs.

E and L RPVs have one major waypoint between launch and target: H. Just prior to H, the operators are required to pop-up the RPV to 3000 feet, change the velocity to 400 knots, prepare the RPV for handover, and signal which pseudo-pilot will control the RPV over target. At H, the pseudo-pilot signaled (which is controlled by a console operator) will flip the appropriate switches on his pseudo-pilot control box to accept control. The pseudo-pilot will then control the RPV through target to the B (handback) waypoint. Near B, control will be released by the pseudo-pilot, and the console operator will change the altitude of the RPV to 200 feet for the return phase.

For S RPVs, there is a major waypoint before H called S. It is just prior to this point that the pop-up maneuver is performed; the velocity is set to 250 knots and the altitude to 3000 feet. At the S waypoint, the RPV is prepared for handover to the terminal pilot. However,

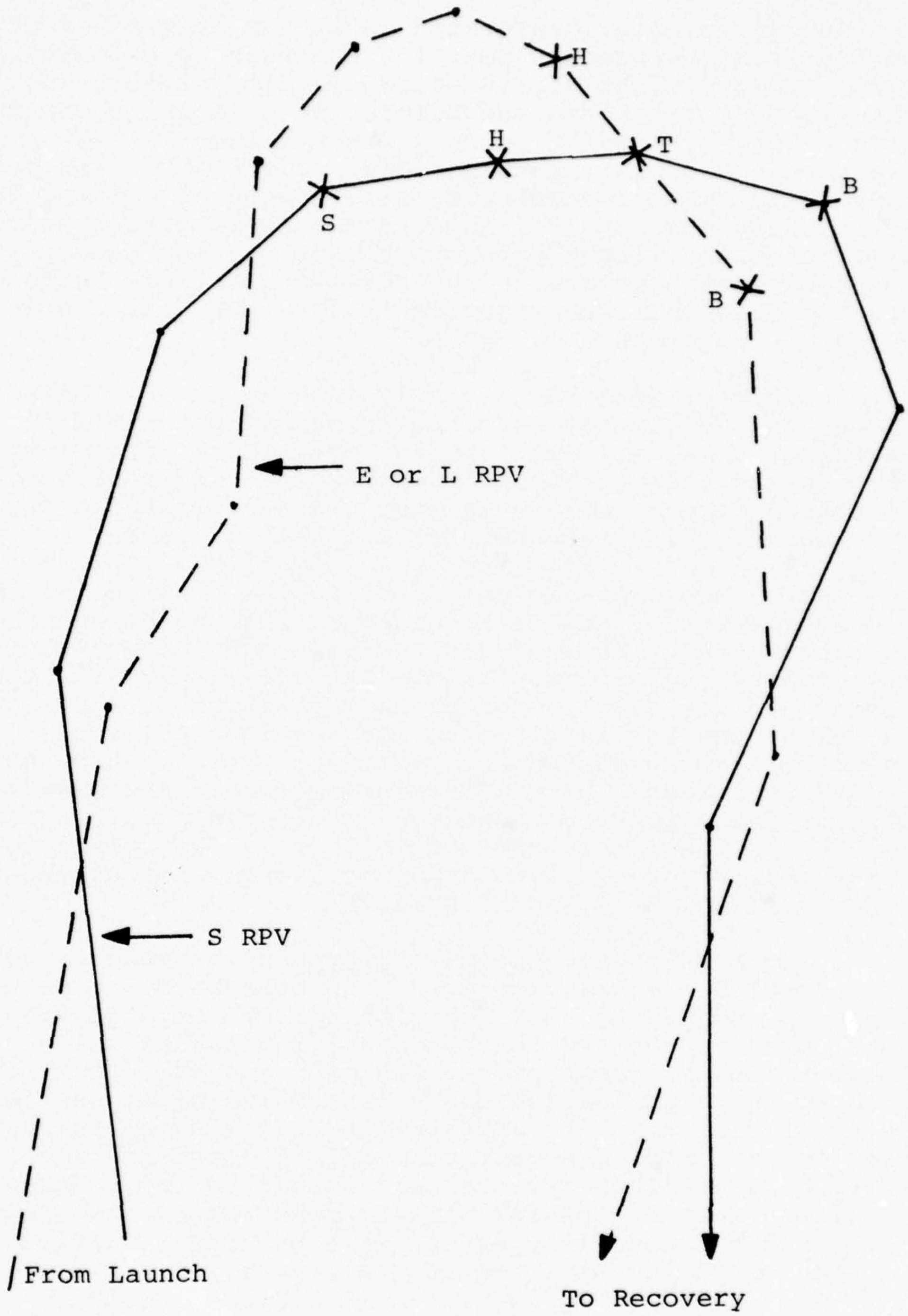


Figure 8. Typical Flight Paths Around the Target Area.

control is maintained by the console operator, who attempts to patch between S and H to keep the RPV on course. When the RPV reaches H, the terminal pilot takes control and flies the RPV through the target area to B. Near B, he releases control to the console operator who pops-down the RPV to 200 feet and changes the velocity back to 400 knots. Also, since the terminal pilot may have flown the RPV widely off course, the console operator may attempt one patch to return the RPV to its original flight path.

Since there is only one terminal pilot, sometimes two S RPVs are scheduled to reach the target at approximately the same time. When this situation occurs, one of the S RPVs will be controlled by a pseudo-pilot during the terminal phase instead of the terminal pilot. All other operations on the S RPV will be performed in the normal manner.

Aside from the three general areas of responsibility discussed above, operators perform other functions that depend on mission conditions. First, operators must monitor the fuel supply to ensure that RPVs have sufficient fuel to return to the recovery area. This activity is performed when all RPVs have completed handoff. If a fuel problem is encountered, the velocity and altitude of the RPV are changed to conserve fuel. Second, operators must respond to malfunctions. If a terminal malfunction occurs, the RPV must be destructed if it is in enemy territory or its chutes deployed if it is in safe territory. If a CL malfunction occurs, the RPV is dropped from the simulation. If a navigation system malfunction occurs, the navigation system must be changed.

If an RPV is lost to the system before it reaches the target area, the operator may attempt to reprogram the mission. For example, an E RPV heading for recovery could be used to replace a lost E RPV that had been travelling to the target area. The activities involved in reprogramming are: 1) the other two RPVs in the group of three containing the lost RPV are slowed to 250 knots, 2) another RPV going to the same target and of the same type as the lost RPV is selected to replace it, 3) as soon as the replacement gets through the target area, it is rerouted back to the target area, and 4) the ETAs of the replacement and the other two RPVs are adjusted to make all three arrive at the H waypoint in the correct sequence.

<u>Operator Performance</u>

As the simulation progresses, the four enroute/return operators scan the CRT displays, request status information,

and generate appropriate commands to the RPVs. The sequence in which operator actions are performed is illustrated in Figure 9.

The highest priority task for an operator concerns the handover operation. From the status information on his CRT display, the operator determines if it is time to prepare one of his assigned RPVs for handoff to the terminal pilot or a pseudo-pilot. If so, the operator initiates a pop-up maneuver on the RPV by changing the altitude and velocity and handing off the RPV to the terminal pilot or pseudo-pilot. Handoffs of RPVs to pilots are generally performed in the following manner: S RPVs controlled by operator 1 to the terminal pilot; RPVs controlled by operator 4 to the pseudo-pilot of operator 1; E RPVs to the pseudo-pilot of operator 3; and L RPVs to the pseudo-pilot of operator 2.

If no handoff operations are to be performed, the operator determines if the terminal pilot, or a pseudo-pilot, has released control of one of his RPVs. If so, he performs a pop-down maneuver to prepare the RPV for the return phase of the mission. If an operator has no handover or handback operations to perform, he checks the ETAs of his assigned RPVs which are in the enroute or return phase of the mission. If there is an ETA correction to be made for an RPV, the operator will change the velocity of the RPV. With no ETA manipulations to perform, an operator will determine if his RPVs are on course. If not, he will initiate a directional change or patch. The enroute/return operator will monitor mission status if he has no pressing responsibilities (none of the above actions was required). Once an operator has performed any action, he will resume his activities with his highest priority operation. Priority among RPVs for the same operation is usually given to the lower number RPV, due to the operators' normal top-to-bottom scanning of the menu.

Operator 4, the "overload operator", has two additional responsibilities that are represented in Figure 9. First, prior to checking for ETA manipulations, he checks for malfunctions and compensates for them by destructing an RPV, causing an RPV to deploy its parachute, or rerouting an RPV on the return phase back to the target area to replace a lost RPV. Second, he checks the fuel levels on all RPVs during the return phase of the mission. If fuel conservation is necessary, he alters the velocity and altitude of the RPVs that are low on fuel.

In observing the real-time simulation in operation, it was found that operators made infrequent use of a number of keyboard functions available to them. "General Display"

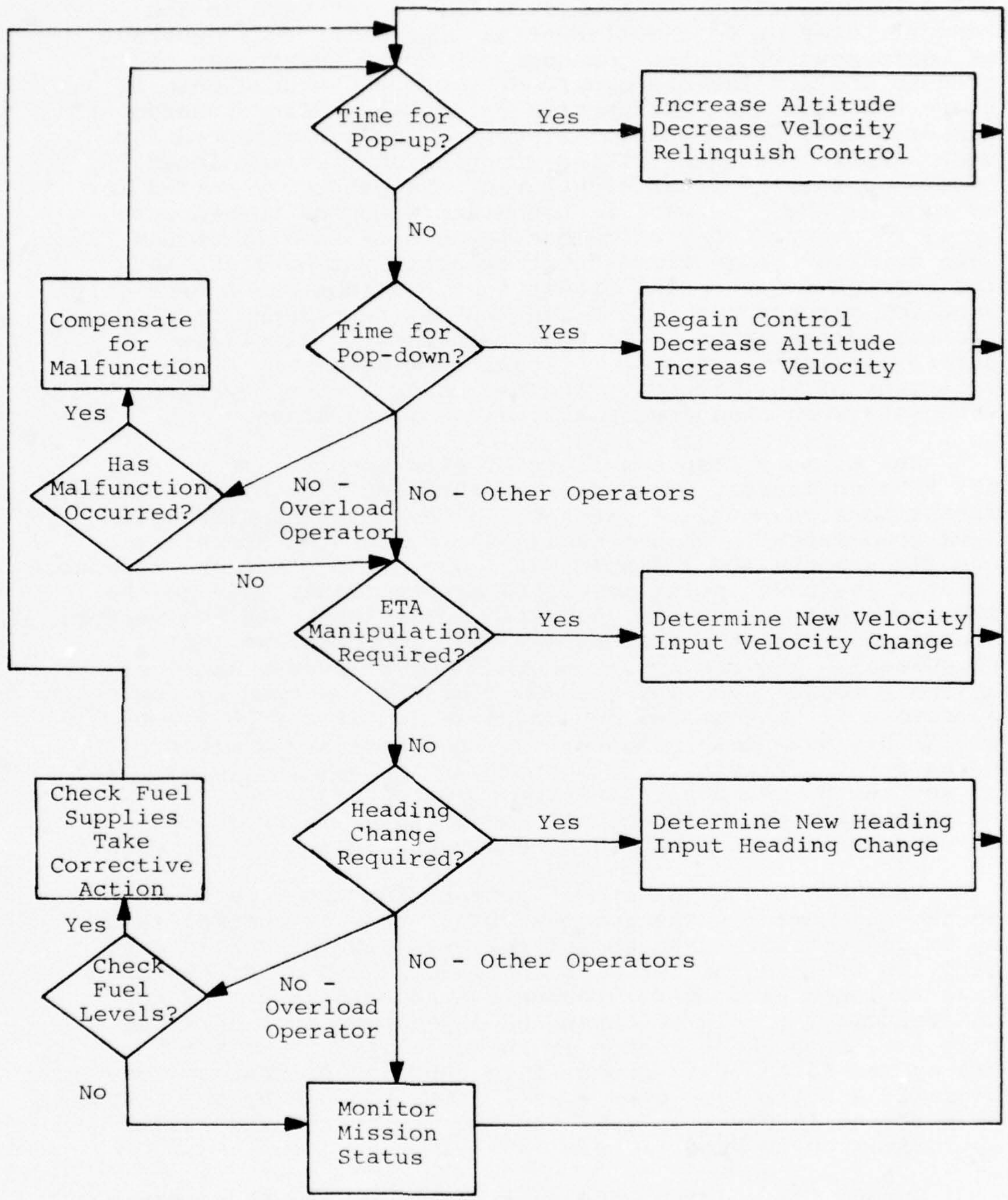


Figure 9. Enroute/Return Operator Activity Sequence.

was only used to survey how close the planes were to the handoff point or to check the FEBA line prior to a destruct or deployment of chutes command. "Display Reset" was never used in the simulations observed. "Drop" was used only if there had been a CL malfunction on an RPV. "Cancel Handover" was used only if the handover command was not accepted for some unknown reason or if the wrong RPV number was input by the operator. Track signatures were generally called for as soon as the RPVs were launched and were not turned off until recovery. "Cancel Command" was only used if CL had been down for some time (commands could not be cancelled fast enough under normal conditions). Flight paths were only used for patches prior to H for S RPVs, reprograms, and extremely large patches. Targets were usually displayed during the entire mission. "Start" was used only at the beginning of the mission. The remainder of the keyboard functions were used frequently, as outlined above.

One primary responsibility of each operator is to keep the RPVs on course. They perform this activity by initiating directional changes, or patches, to the RPVs when the RPVs have gone astray. In performing the patch, the operators usually use the MOD 3 display with one patch point and reconnect point. The patch point is placed on the flight path of the RPV three dots above the velocity vector (the dots and vector are display elements that appear when MOD displays are requested). The reconnect point is generally the last dot on the screen. However, the MOD 2 display is used by the operators if the lateral deviation is as high as 3000 feet or if they have been unsuccessful in generating a patch using a MOD 3 display. With a MOD 2 display, the patch point is set one or two dots above the velocity vector and the reconnect is two or three dots above that. In addition, patches are never attempted around turns in the flight path.

Another of the operators' primary functions is to set up the appropriate ETAs for the RPVs. This is accomplished by making velocity changes for the RPVs and is usually done early in the mission for ETAs to handoff, and after the RPVs have finished handoff for recovery ETAs. To determine the new velocity, a rule of thumb and experience is used. The rule is: A one knot change in the velocity will alter the ETA by one-fifth of a second if the RPV is 30 minutes from handoff; and the same change will alter the ETA by two-fifths of a second 15 minutes from handoff. In between, a linear approximation is used.

During the mission, the fuel supply of the RPVs must be checked to ensure that the RPV has sufficient fuel to reach the recovery area. Operator 4 checks these fuel supplies after all RPVs have been through handoff. He determines if

the RPV will reach recovery at its present fuel consumption rate; if not, he changes the RPV altitude and velocity in order to ensure RPV arrival at the recovery area. It has been determined by the operators that a velocity of 310 knots at an altitude of 10,000 feet is most efficient in terms of fuel consumption.

SECTION III

THE SAINT MODEL OF THE RPV/DCF REAL-TIME SIMULATION

The development of a non-real-time computer simulation model can be of tremendous value when used in conjunction with the real-time simulation for the evaluation of alternative system configurations and operational procedures. The advantages from this type of cooperative study are in computer time, personnel organization, and expense. Also, as with any major computer application, the value of a back-up system to verify and check programming procedures is incalculable. Thus, a model of the real-time RPV/DCF simulation was constructed and validated against the real-time system using the newly developed man-machine simulation language, SAINT. The model development and subsequent analysis of results demonstrate the power and usefulness of SAINT in the analysis of man-machine systems. This section presents the SAINT simulation of the RPV/DCF real-time simulation currently being used to study RPV/DCF system design and operation.

The SAINT model of the real-time RPV/DCF simulation has been built to accurately represent the real-time simulation discussed in Section II. An overview of the SAINT model is presented in Figure 10. The state variable model component consists of the simulation of RPV flight positions, navigation system errors, acceptance of operator commands by the RPVs, RPV maneuverability limitations, fuel consumption, and the effect of flight disturbances. The task-oriented model component includes all control and decision tasks performed by the DCF operators during a mission. The interactions between the state variable and task-oriented model components represent the display of status information on the operators' consoles and the transmission of commands to the RPVs.

State Variable Model Component

The state variable portion of the SAINT model duplicates the RPV flight of the RPV/DCF real-time simulation as discussed in Section II. In performing this duplication, RPV characteristics and the RPV simulation environmental factors are input to the SAINT model in the same form and manner as for the real-time simulation. This will be referred to as "AMRL data". Thus, the parameter values for the distributions of the navigation system errors and position reporting errors, the flight plans of the RPVs, the parameters for jamming, the fuel levels on the RPVs, the fuel consumption rates of the RPVs, the malfunctions occurrring to the RPVs, and the type of each RPV are input

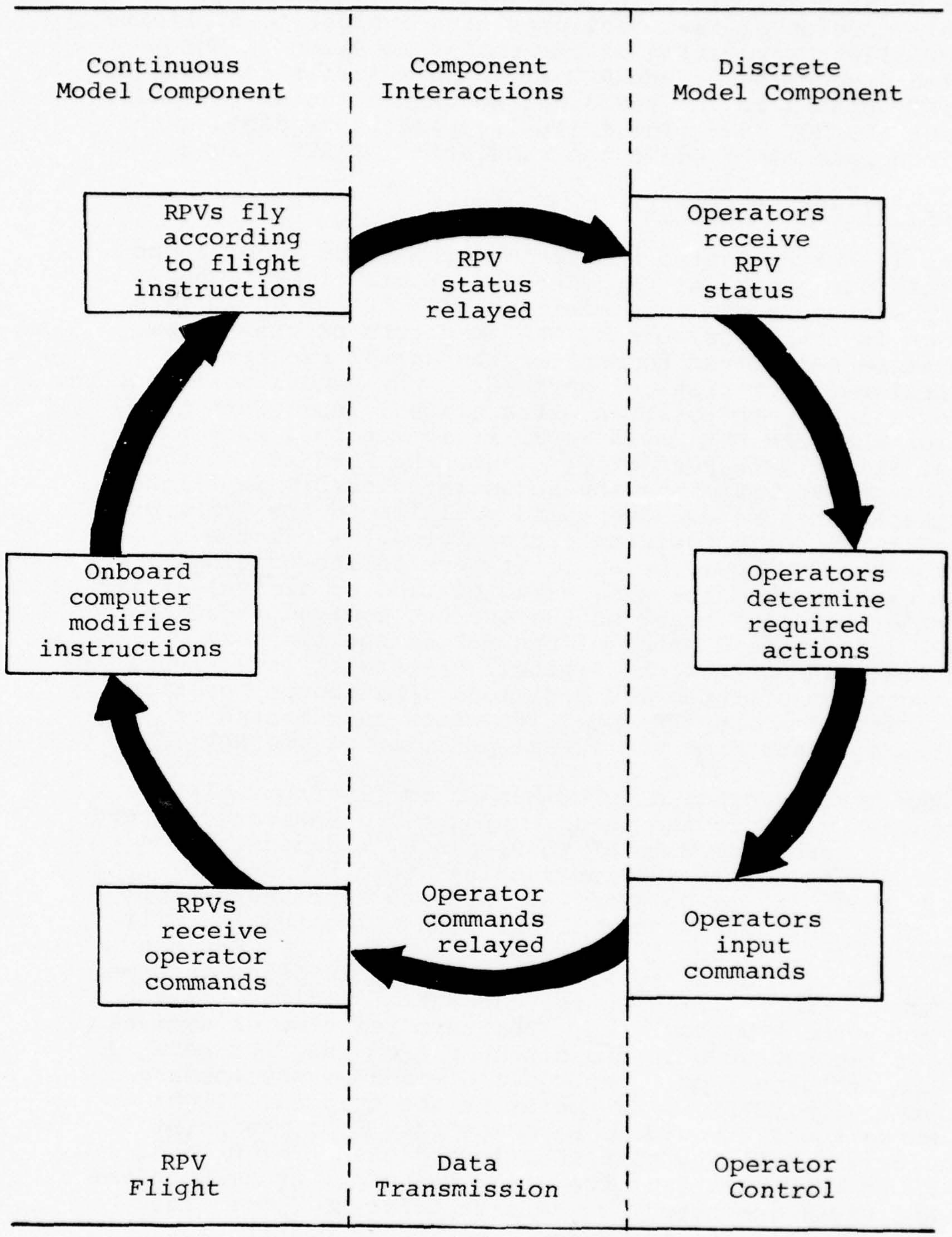


Figure 10. Overview of the SAINT Model of the RPV/DCF Simulation.

to the SAINT model directly from AMRL data. The state variable portion of the model uses these values to duplicate the RPV flight simulation of the real-time system. The detailed discussion of the RPV flight simulation as designed in SAINT appears in the technical documentation of the SAINT model of RPV/DCF (9). The following paragraphs discuss the SAINT concepts employed in the simulation of RPV flight.

RPV Flight Positions

As in the real-time simulation, the SAINT model keeps track of four positions for each RPV at all times. The first position is the true position (TP) of the RPV. This position is not accessable by the operators of the system, but must be maintained to monitor the actual progress of the mission for statistical purposes. The second position, the FPPE or flight path position extrapolated, represents the position that the RPV would be at if it was following the current flight path perfectly. Thus, the FPPE is the true position of the RPV minus any accumulated errors in flight that the RPV has made. The third position is the VFPPE or virtual flight path position extrapolated. It is the position the RPV would be at if it were on its original flight path and had the same expected time of arrival at its next major waypoint based on the current command speed of the RPV (the command speed of the RPV is the speed at which it is supposed to be flying). Figure 11 is a visual representation of these RPV positions (the fourth position is a position report (PR) position which is computed at each frame update from the actual position of the RPV).

The RPV was originally commanded to fly from point A through B and C to the major waypoint D. However, the RPV flew off course from A to B' to P. At P, a directional patch was sent to the RPV instructing it to fly from P through X_1 and X_2 to D. The P-X_1-X_2 path represents the modified flight path or the flight path which the RPV will attempt to fly. Since the time of the patch, the RPV has again flown off course to X_1' and TP. At this point in time, the FPPE is the position on the current or modified flight path where the RPV should be. The expected time of arrival (ETA) of the RPV at D is the distance from the FPPE to X_2 plus the distance from X_2 to D all divided by the command velocity. The VFPPE is the point on the original flight path where the RPV would be based on this ETA; the point on the original flight path that is a distance of D to X_2 plus X_2 to FPPE back from the major waypoint, since both the FPPE and VFPPE are based on the same velocity. Both the FPPE and PR positions are used by the operators in order to control the mission. The TP and VFPPE are used for statistical evaluation purposes to determine the actual deviation from the flight path that each RPV records.

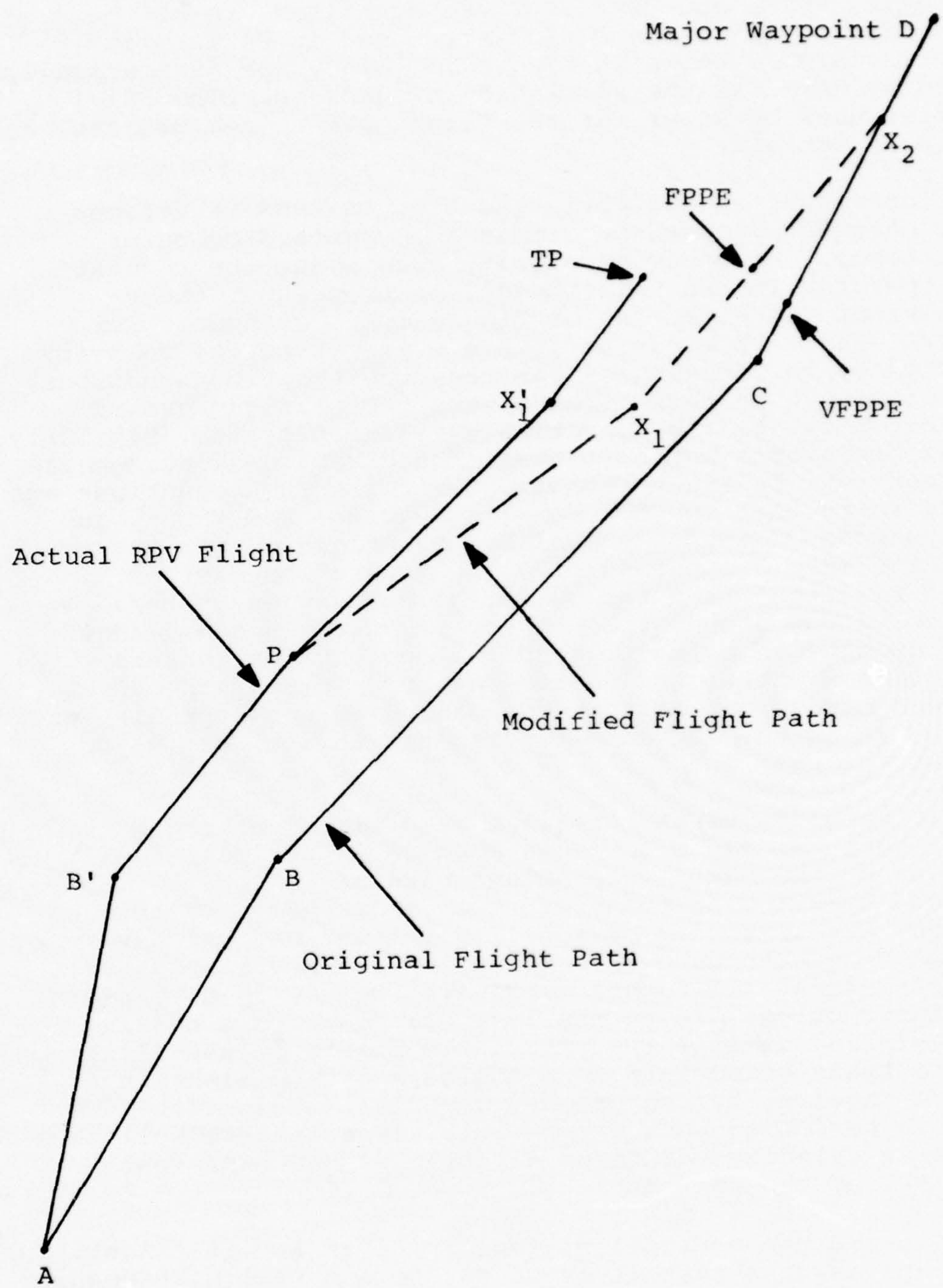


Figure 11. True Position, FPPE, and VFPPE for an RPV.

State Equations and Modifications

Six state variable equations are employed by the SAINT model for each RPV to record the X and the Y coordinates for the TP, FPPE, and VFPPE. These equations are of the form appearing in Figure 12 and are coded in FORTRAN in subroutine STATE, shown in Figure 13. They are automatically updated by SAINT as the simulation progresses. The SS(·) variables used by SAINT for the flight path positions are defined in Table V.

The values of the variables used in these equations may be changed by operator commands or onboard computer instructions. Whenever a velocity change, at the request of an operator in the SAINT model, is processed, the v component of the equations of Figure 12 is changed. For the FPPE and VFPPE equations, this v is set to the velocity requested by the operator. For the true position equations, the v component is this command velocity plus the ground speed error due to the operating navigation system. Similarly, when an operator's patch (request for directional change) is processed, the h_x and h_y components of the FPPE equations are changed to reflect the new command heading; and the h_x and h_y components of the true position equations of the RPV are set to the FPPE components plus the ground speed error factors resulting from the operating navigation system. In addition, a new ground speed error is determined and added to the command velocity to obtain a new v value for the true position equations. In the case of a patch, the VFPPE equations may or may not change heading values depending on the new ETA of the RPV and its distance to its next major waypoint.

In response to the original RPV flight path, the onboard computer may also cause changes in the position equations of the RPVs. The flight path of an RPV is described by a set of points in the geographic area through which the RPV is to fly at specific velocities. At any point in time, the onboard computer of the RPV carries instructions for all future maneuvers the RPV is to perform. These instructions are in the form of: "turn to a heading of h beginning at time t." Thus, the points on the flight path are transformed into turn angles and turn times when they are received by the onboard computer. This transformation is performed upon flight initialization, as well as whenever a velocity change or directional patch is sent to the RPV by the operators.

Time is the controlling factor for an RPV in flight. The RPV always assumes that it is on course and will make heading changes at the exact time prescribed regardless of its true position(errors in the electronic clocks onboard the RPVs are

$$x_t = x_{t'} + h_x v(t-t')$$

$$y_t = y_{t'} = h_y v(t-t')$$

where

t	is the current value of simulated time
t'	is the time of the last threshold crossing or task completion
x_t	is the x-coordinate of the RPV position at time t
y_t	is the y-coordinate of the RPV position at time t
h	is the heading of the RPV with respect to the positive x-axis
h_x	is the cosine of the heading
h_y	is the sine of the heading
v	is the velocity of the RPV

Figure 12. Equations Governing RPV Positions.

```
      SUBROUTINE STATE
      ************
      COMMON CARDS
      ************
      SS(71)=SS(71)+DTNOW
      DO 10 I=1,NRPV
      I1=I+103
      I2=I+119
      I3=I+71
      I4=I+87
      I5=I+135
      I6=I+151
      SS(I1)=SSL(I1)+TSPED(I)*XHEAD(I)*DTNOW
      SS(I2)=SSL(I2)+TSPED(I)*YHEAD(I)*DTNOW
      SS(I3) =SSL(I3)+SPEED(I)*TXHED(I)*DTNOW
      SS(I4)=SSL(I4)+SPEED(I)*TYHED(I)*DTNOW
      SS(I5)=SSL(I5)+TSPED(I)*VXHED(I)*DTNOW
      SS(I6)=SSL(I6)+TSPED(I)*VYHED(I)*DTNOW
   10 CONTINUE
      RETURN
      END
```

Figure 13. Subroutine STATE.

TABLE V

SAINT SS(·) VARIABLES FOR RPV FLIGHT POSITIONS

SS(·) VARIABLES	DEFINITIONS
SS(72) - SS(87)	True X-position of RPV I, I = 1-16
SS(88) - SS(103)	True Y-position of RPV I, I = 1-16
SS(104) - SS(119)	FPPE X-position of RPV I, I = 1-16
SS(120) - SS(135)	FPPE Y-position of RPV I, I = 1-16
SS(136) - SS(151)	VFPPE X-position of RPV I, I = 1-16
SS(152) - SS(167)	VFPPE Y-position of RPV I, I = 1-16

considered negligible). Thus, navigation system errors will not be corrected for by the RPV inflight. The RPV assumes it is flying exactly as it should.

The RPVs fly from coordinate to coordinate in a linear fashion. The simulation of RPV flight is a linear two-dimensional approximation. RPVs fly from point to point in straight line segments. However, this approximation does not imply that RPV maneuverability is ignored. Rather, all flight paths and flight path modifications are initally computed as if the RPV would fly a path composed of linear segments and circular arcs. The circular arcs are then approximated by chords that never exceed fifteen degrees of turn.

The processing of flight path turns in the SAINT model is accomplished by using a combination of state variables and state variable monitors. The value of state variable SS(I) is the time of the next turn on the FPPE flight path for RPV I. The value of SS(71) is set to TNOW, the current value of simulated time. As shown in Figure 14, state variable monitor I is used to monitor the values of SS(I) and SS(71). When the monitor detects the value of SS(71) crossing the value of SS(I), task 92 of the task-oriented model component is signaled and the value of logical switch 1 is set to I, the number of the RPV preparing to turn. Task 92 initiates a change in the values of h_x and h_y in the FPPE equations, and the values of h_x, h_y, and v (including navigation system errors) in the true position equations. The RPV is then on course to its next flight path turn point. In a similar fashion, as shown in Figure 14, SS(36) through SS(51) and monitors 17 through 32 signal task 93 and set logical switch 2 for processing of VFPPE flight path turns.

Monitor 33 is used to detect the end of the simulation. It monitors the value of SS(168), which it set to 0 at the start of the simulation and 2 when all RPVs have been recovered. When monitor 33 detects the value of SS(168) crossing a value of 1, task 94 is signaled. Task 94 is a sink task. Its completion causes the end of the simulation.

<u>Task-Oriented Model Component</u>

The task-oriented component of the SAINT model of the real-time RPV/DCF simulation represents the control and decision tasks performed by the DCF operators during a mission.

The majority of the operator tasks in the SAINT network are either tasks, tasks that can be performed by any of the operators specified. The use of either tasks allows a single

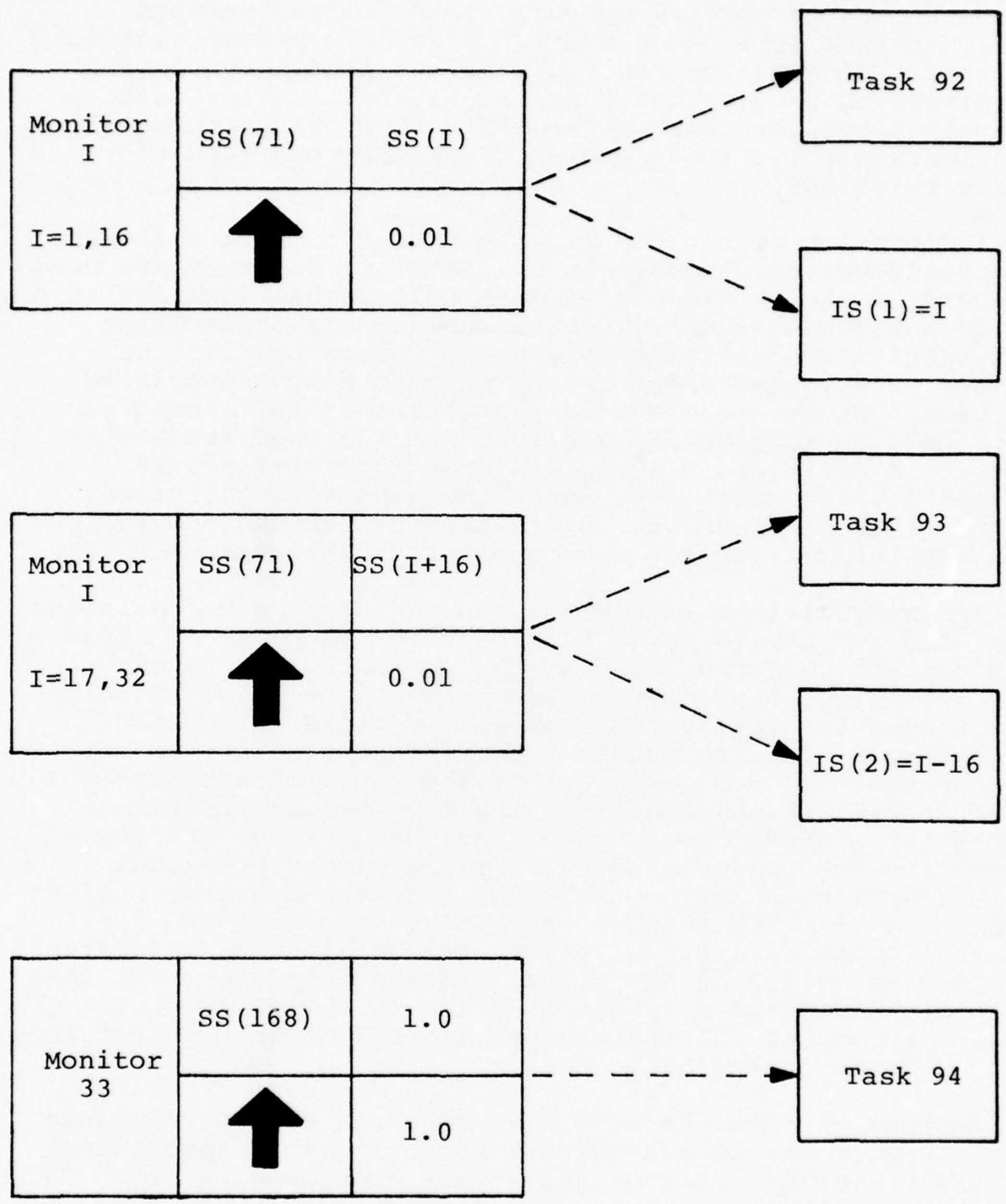


Figure 14. State Variable Monitors.

SAINT network to represent the control of all RPVs by all DCF operators. In actual operation, the single network represents four separate networks performed by four distinct operators. Information and operator attributes are used extensively to provide the necessary quantities for task performance by different operators. Operators perform all tasks individually, in an order dictated by the task precedence relations.

Information attributes flow from task to task following the precendence relations. In the SAINT model, they are used to record necessary quantities available at one task and supply them to subsequent tasks. For example, operator decision tasks require the operator to search through his list of assigned RPVs to determine if any of them meet a specified condition. Whenever an RPV is found to meet the conditions prescribed, an information attribute is assigned the RPV number. In addition, a second information attribute is assigned a value which represents the condition satisfied. The quantities assigned to information attributes provide necessary information for subsequent task performance.

In the real-time simulation, an operator makes decisions as to when and how to perform certain tasks. Some of these decisions are characteristic of the particular operator. Thus, to represent the system accurately, the SAINT network must be able to distinguish between operators. Operator attributes are used to ensure that differences in operators are represented. Some examples of the operator attributes used in the SAINT model are: 1) the time before the RPV reaches its handoff coordinates that the operator prefers to initiate the pop-up maneuver; 2) the times before the RPV reaches its handoff coordinates that the operator prefers to make the velocity change, the altitude change, and the handover to the terminal pilot or pseudo-pilot; 3) the lateral deviation value for an RPV above which the operator will make a directional change for that RPV; and 4) the difference between the actual ETA and the desired ETA of an RPV that the operator deems acceptable.

Another point to be made here concerns task performance times. Some tasks representing operator actions have times that are primarily operator dependent. For example, the time that it takes to input a velocity change is the time it takes the operator to press the appropriate buttons. Actions such as this have times that are governed by distributions. Other tasks in the network are needed to maintain the structural integrity of the network or to pass information between the two components of the model. These tasks take zero time to perform. There are some tasks whose times are

dependent on RPV status or operator attributes. For example, when an operator wants to make an RPV directional change, he pushes buttons to have the appropriate information displayed. However, he cannot make the patch until the information is displayed. Since the displays appear at five-second intervals, he may wait zero to five seconds for this update, depending on the mission time at which he made his request. The time for this task is computed by a moderator function as the time to the next frame update, at which time the operator inputs the points through which he wants the RPV to fly. Other examples of tasks where moderator functions are used to compute performance times are tasks where the operator waits for the results of his most recent command; tasks where the operator waits until a specific time prior to the RPV reaching its handoff coordinates before he performs an action; and the task representing the operator monitoring mission status whose performance time depends on the time until the operator's next scheduled pop-up maneuver. Moderator functions are also used throughout the network to determine or alter task performance due to system and environmental conditions and to record operator and RPV status information.

The SAINT network is shown in Figure 15. The basic structure follows the form of operator activities as outlined in Figure 9. A general discussion of the tasks in the SAINT network is presented below. A complete description of these tasks appears in the technical documentation (9).

Monitoring Mission Status

The SAINT simulation begins with all enroute/return operators observing the progress of their assigned RPVs (18)[1]. This task, monitoring mission status, is performed by an operator whenever he is not required to perform any other tasks related to his assigned RPVs. Following the monitoring of mission status, operators proceed to task 91, where they begin a sequential consideration of tasks to perform.

Handover/Handback

At task 91, the operator determines if it is time to perform a pop-up maneuver for one of his assigned RPVs. If so, he turns on the flight path display (S RPVs), waits until his preferred time to input the altitude change, and performs the keyboard functions to request the altitude change (27). He then waits until his preferred time for the velocity change and performs the appropriate keyboard functions (29). Following the velocity change, the operator

[1]Numbers in parentheses refer to the tasks numbers as shown in Figure 15.

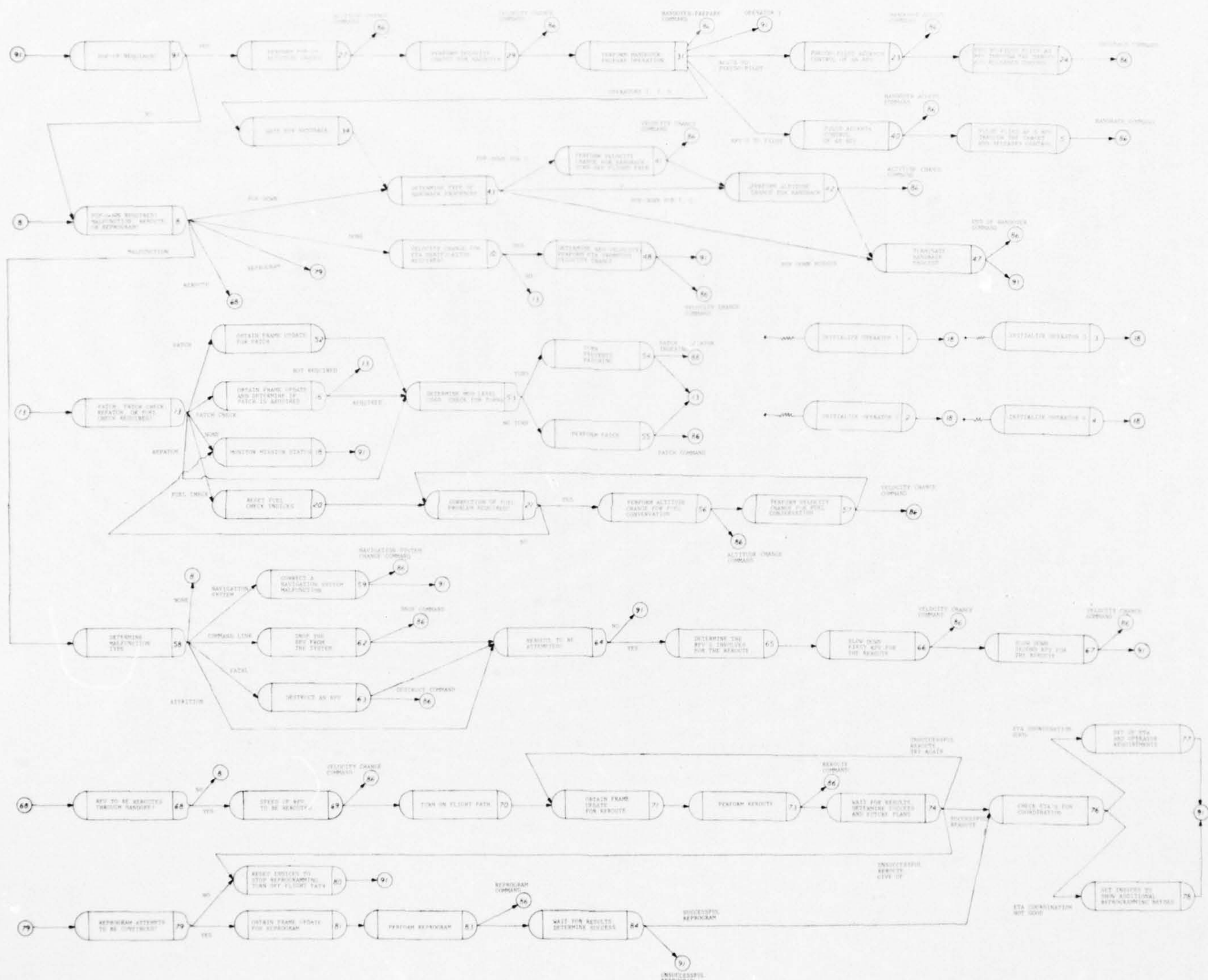


Figure 15(1). Task-Oriented Component of the SAINT Simulation Model.

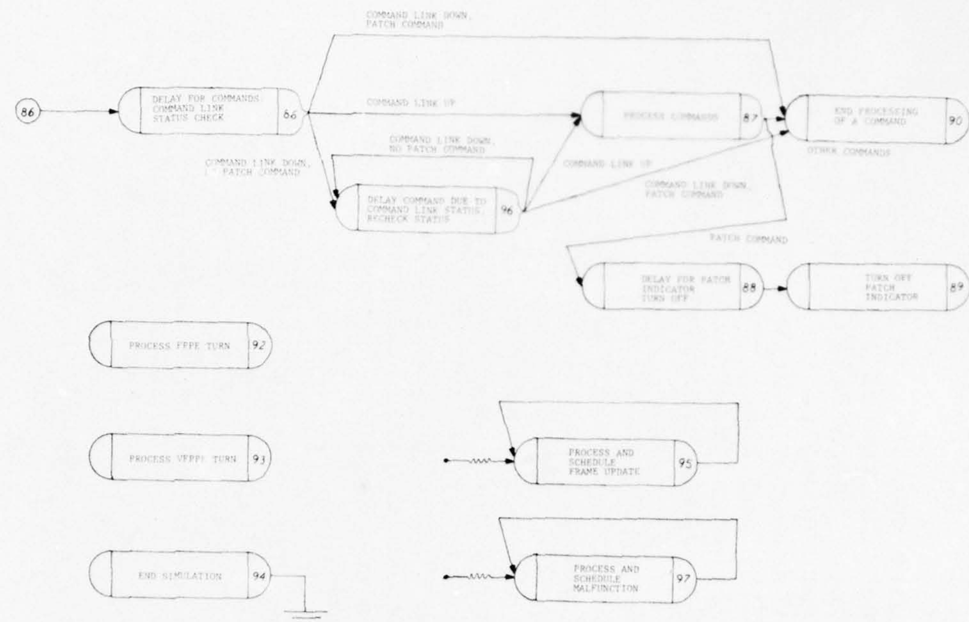


Figure 15(2). Task-Oriented Component of the SAINT Simulation Model.

waits until his preferred time for the handover-prepare operation and inputs the prepare command (31). If this is operator 1, he returns to task 91 to determine if other pop-ups need to be performed. Other operators wait until the RPV is handed back (34) and perform the pop-down maneuver (43).

After the handover-prepare command has been input (31), the RPV is flown through the target area by the terminal pilot or pseudo-pilot. The S RPVs handed to the terminal pilot (operator 9) are accepted by the pilot (40) and flown through the target area (5). RPVs handed to pseudo-pilots are accepted (23) and flown through the target area (24). RPVs that never achieve terminal pilot or pseudo-pilot control fly through the target area according to their onboard flight paths.

If no pop-up maneuvers are called for at this time, the operator next checks to see if the terminal pilot or a pseudo-pilot has released an RPV to him (8). If so, the activities required for the pop-down maneuver for this RPV are determined (43). For S RPVs, the velocity is changed and the flight path display is turned off (41). For all RPVs that are popped down, the altitude is changed (42) and the maneuver is completed (47). If the pop-down was missed (43), the maneuver is completed (47) without the altitude and velocity changes.

If operator 4 determines that none of his assigned RPVs are to be popped down at this time, he determines if a malfunction has occurred (8). If so, he will either correct the malfunction (58), reroute an RPV back through the target area (68), or attempt to adjust the ETA of a rerouted RPV to correspond to the ETAs of the other two RPVs associated with the rerouted RPV (79). If no malfunctions have occurred, or if this is not operator 4, processing is continued at task 10.

Enroute/Return

If no pop-down maneuvers or malfunction corrections were required (8), the operator determines if a velocity change is necessary to improve the ETA of one of his assigned RPVs (10). If so, the operator computes the new velocity and inputs the velocity change command for this RPV (48).

If no ETA adjustments are required at this time, the operator will consider patches to be performed (13). Operators have a variety of rules to determine if a patch is to be performed. Task 13 checks the rules to determine if a patch is to be performed and directs the operator to the appropriate task. If an operator decides to patch an RPV because its

lateral deviation alarm number is too large, he requests his preferred patching MOD display and waits for the frame update (52). He then performs the patch (53). If an operator checks the actual lateral deviation before making a patch, he requests a MOD display, waits for the frame update, and checks the lateral deviation value (16). If the value is too large, he patches the RPV (53); if not, he checks to see if any other of his assigned RPVs need to be patched (13). If an operator has already made a patch on an RPV and decides to repatch, he performs the repatch immediately (53).

Prior to performing a patch on an RPV, the operator determines if a turn point on the RPV flight path is imminent (53). If so, he delays making the patch (54) and returns to consider making patches on other RPVs (13). If not, the MOD display preferred by the operator is accessed (53), and the operator inputs the patch and reconnect points (55). After inputting a patch, the operator returns to consider making additional patches (13).

After operator 4 completes all necessary patches, he determines if it is time to check the fuel supply of each RPV (13). If so, the time of the fuel check is recorded (20). Operator 4 will then determine if any of the RPVs are in danger of not being able to reach the recovery area at their present fuel consumption rate (21). If an RPV is low on fuel, he changes its altitude (56) and velocity (57). Operator 4 then continues to check the fuel supplies of other RPVs (21).

After all necessary patches have been made and all fuel levels have been checked, the enroute/return operators monitor mission status (18).

Malfunctions

Operator 4 corrects malfunctions (58) whenever he determines that one has occurred (8). If the malfunction has already been corrected, he returns to other duties (8). If the malfunction has not been corrected, he determines the type of malfunction that has occurred (58). If a navigation system malfunction has occurred, operator 4 determines the new navigation system to be used and inputs the navigation system change command (59). For a command link malfunction, he drops the RPV from the system (62) and considers a possible rerouting of an RPV to replace the one that was dropped (64). If a terminal malfunction has occurred, he inputs a destruct or chutes command (63) and considers a possible reroute (64). If an RPV was lost due to enemy or terrain consideration, operator 4 proceeds directly to the rerouting determination (64).

Once an RPV is lost, operator 4 determines if it is possible to reroute another RPV to replace it. If not, he returns to his other duties (91). Otherwise, rerouting indicators are set (65) and the velocity of the two RPVs associated with the lost RPV are decreased (66, 67).

If a rerouting operation is to be performed (8), operator 4 determines if the RPV to be rerouted has been handed-off to the terminal pilot or a pseudo-pilot. If not, he resumes his malfunctions check (8). If so, he increases the velocity of the RPV to be rerouted (69), turns on its flight path display (70), accesses the appropriate MOD display and waits for the frame update (71). He then generates the new flight path (73) and waits for the results of his rerouting operation (74).

Due to the maneuverability constraints on the RPV, it is possible for the rerouting attempt to be unsuccessful. If it is, operator 4 will try again (71). He will attempt to reroute an RPV up to four times. Following his fourth unsuccessful attempt, he makes no additional attempts and turns off the flight path display (80).

If operator 4 has been successful in generating a flight path for the RPV back to the target area, he determines if the ETAs of the three RPVs involved can be synchronized (76). If so, the flight path of the rerouted RPV is turned off and the new ETA requirements are determined (77). If the ETAs cannot be synchronized, the new flight path must be modified (reprogrammed).

When operator 4 determines that a rerouted RPV must be reprogrammed (8), he decides if an attempt should be made (79). As with the rerouting operation, operator 4 will make only 4 attempts to coordinate the ETAs of the three RPVs involved. In addition, he will discontinue reprogramming attempts if one of the two slowed RPVs comes within two minutes of its handover waypoint. If operator 4 does not attempt a reprogram, he turns off the flight path display of the rerouted RPV (80) and returns to other duties.

If operator 4 decides to reprogram an RPV, he accesses the MOD 1 display and waits for the frame update (81), inputs the new flight path points (83), and waits for the results (84). If the reprogram was successful, he will check for ETA coordination. If not, he returns to his other higher priority duties (91) before attempting another reprogram.

Interactions Between State Variable and Task-Oriented Model Components

From the SAINT model overview provided in Figure 10, it can be seen that two distinct mechanisms are required for interaction between the state variable and task-oriented components of the model. First, RPV status information computed in the state variable component must be made available to the operators in the task-oriented component. Second, commands initiated by the operators must be supplied to the state variable component for processing. Information attributes and user-written support routines provide the mechanism for the necessary interactions.

RPV Status Information

Task 95 represents the time between updates of the CRT display in the real-time simulation. This task is completed every five seconds. Upon each completion, all required RPV status information is updated. This information includes the status of the communication links (up or down), the fuel remaining onboard the RPVs, the estimated (PR) positions of the RPVs, the estimated cross track errors (lateral deviation) of the RPVs, and the lateral deviation alarm numbers of the RPVs.

Whenever an operator requires RPV status information in order to make a decision at a task, the user-written assignment function (function USERF) is called. This function assigns the values of the required RPV status variables to designated information attributes. The values of these information attributes are then used as branching parameters in the network.

As an example, consider the decision to be made at task 16. The operator must determine whether or not to patch an RPV. If the lateral deviation of the RPV is greater than the operator's required value, information attribute 3 is set to 1. This causes the branch to task 53 to be selected, initiating the patching process. If the lateral deviation is not greater than the required value, information attribute 3 is set to 0, allowing the operator to return to task 13 to consider patches on other RPVs.

In the manner described above, all RPV status information necessary for the control of RPV flight by the enroute/return operators is passed from the state variable component of the model through the user-written assignment function to information attributes for use by the operators in selecting tasks to perform.

Command Processing

Whenever a task in the task-oriented component of the SAINT model represents the operator requesting that a command be sent to an RPV, information attributes are assigned values that completely define the command. Information attributes 2, 4, and 5 are assigned, respectively: the RPV number to which the command pertains; a command code which specifies the type of command requested; and the value associated with the command (if one is required). This information is then directed to the command processing portion of the network, beginning with task 86.

Task 86 represents the time delay between the time a command is requested by an operator and the time it is actually received by the RPV. At the end of this time, the status of the command link to this RPV is determined. If the command link is down, the sending of the command will again be delayed, after which the command link status check is repeated (96). Whenever the command link is found to be operative, the command is processed (87). Task 87 accesses a user-written moderator function. The moderator function passes the values of the appropriate information attributes to the state variable component where the processing of the command is completed.

As an example, consider the sequence of tasks beginning with task 57. For explanatory purposes, assume that RPV 15 is running low on fuel. This situation requires operator 4 to decrease the velocity of RPV 15 to 310 knots. To make this adjustment, operator 4 must perform the keyboard functions required to input the command. Task 57 represents this operation.

At task 57, the information attributes are assigned the values which define the velocity change command. Information attribute 4 is assigned a value of 3, the command code for a velocity change, while information attribute 5 is assigned a value of 310, the desired velocity (information attribute 2 was assigned the RPV number at task 22). Upon completion of task 57, the information packet containing the attributes described above is directed to task 86.

At task 86, the command information stored in the information packet is delayed. Following the delay, assuming that the necessary command link is up, the packet moves to task 87 for processing. A moderator function is called to retrieve the attribute values. A user-written subprogram is called from the moderator function with the command information as the arguments. The subprogram then alters the appropriate state variable coefficients.

SECTION IV

MODEL EVALUATION PROCEDURE AND PRESENTATION OF VALIDATION RESULTS

The SAINT model of the RPV/DCF real-time simulation was evaluated by comparing the values of the system performance measures outputted to those of the real-time simulation. A single sample mission performed by a single set of operators was selected as the basis for the evaluation. The mission selected included 16 RPVs and was performed by operator group 1. Both mission profile and operator characteristics data serve as input to the SAINT model. This input data made the general SAINT model both mission-specific and operator-specific. The mission profile data employed was identical to that used by the real-time simulation. The operator characteristics used represent the five operators that comprise group 1.

The RPV/DCF real-time simulation was designed to study system performance as a function of system parameters, such as mission profile and RPV characteristics. For this purpose, the real-time simulation outputs statistical measures of system performance. The SAINT model of the real-time simulation was designed to provide the same or expanded outputs of system performance. This allowed a direct comparison of the results of the two simulations to be made.

Model Evaluation Procedure

The model evaluation procedure employed is depicted in Figure 16. The SAINT simulation was run and the detailed outputs from the SAINT and the real-time simulations were compared. (Detailed outputs are the status reports for the RPVs presented every five seconds. Summary statistics are values computed after a simulation averaged over all RPVs.) If serious discrepancies between correspoinding outputs existed, the structure of the SAINT model as well as the parameters of the model were studied carefully and modifications were made where necessary. The simulation was then rerun and the detailed output comparison was repeated.

When no significant differences were found between the detailed outputs of the SAINT and real-time simulations, the summary statistics generated by the two simulations were compared. Replications of the SAINT simulation were performed to provide a basis for statistical analysis and validation. If significant differences between the two simulations were discovered at this point, the structure and parameters of the SAINT model were re-analyzed and modifications were made where appropriate. After these alterations, the evaluation

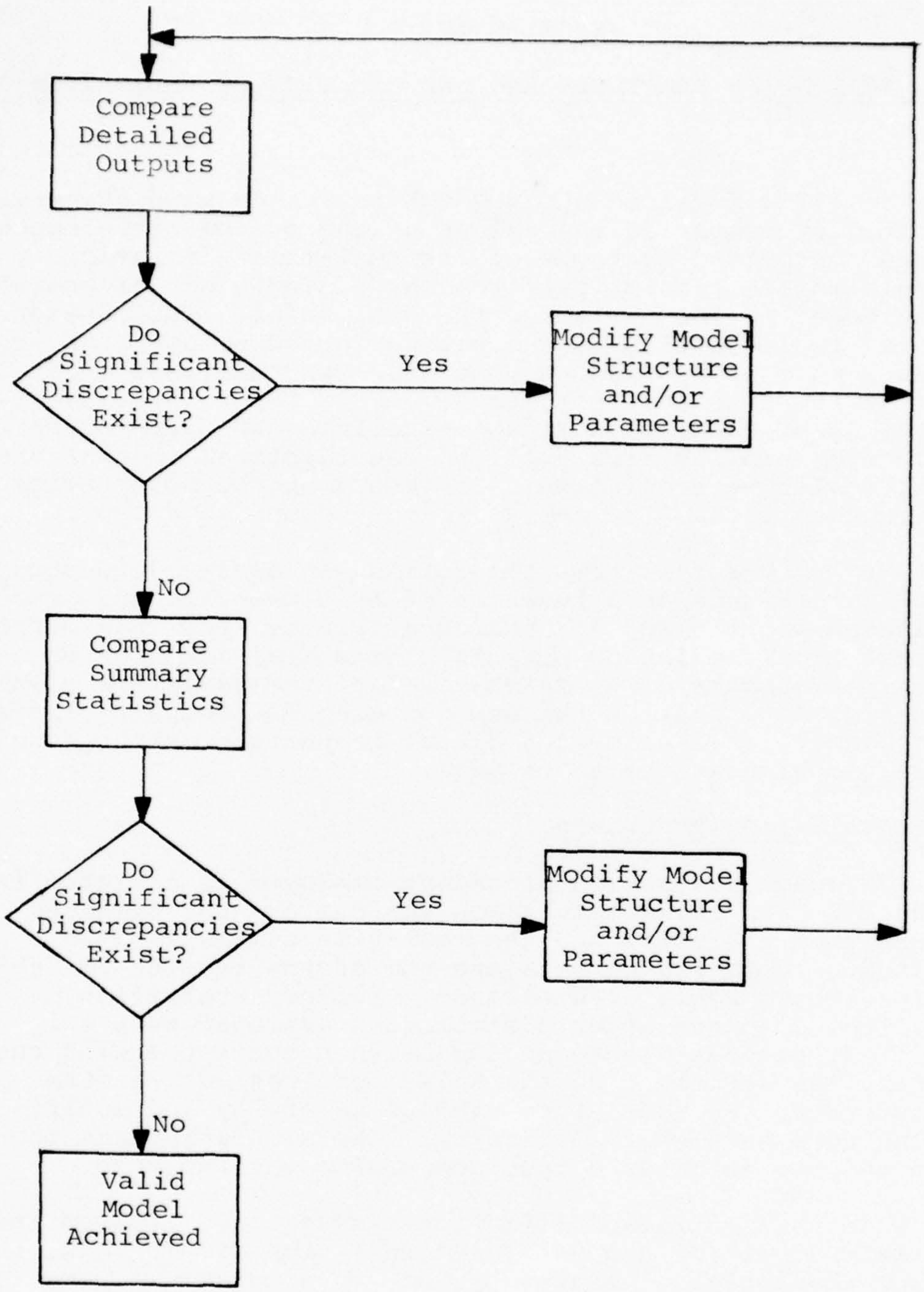


Figure 16. Model Evaluation Procedure.

process continued by once again examining the detailed outputs of the simulations.

The entire evaluation procedure was continued until no significant discrepancies existed between either the detailed outputs or summary statistics of the two simulations, or in other words, until the SAINT model was found to be a valid representation of the real-time RPV/DCF simulation for the mission studied.

During the model evaluation process, two major types of modeling inaccuracies were discovered that resulted in significant discrepancies between the SAINT and the real-time outputs. The first type involved inaccuracies in the modeling of operator performance. The model of operator duties, represented by the task-oriented component of the SAINT model, was developed through actual experience on the system, observation of the operators, and discussions with the operators. However, operators do not always function as they describe and are not always consistent in their actions. Thus, in some cases the results of the evaluation procedure indicated that corrections were required to alleviate the modeling inaccuracies that resulted from the misrepresentation of operator performance.

The second major type of modeling inaccuracies encountered resulted from the misrepresentation of real-time system performance. In some cases, parameter values used in the real-time simulation were not those that had originally been documented. For example, the ground speed navigation system errors for the RPVs were intended to have means that were 10 times the values actually used. Thus, when the SAINT model used the values specified in the RPV/DCF documentation, the SAINT outputs were found to be significantly different from the real-time simulation outputs. In another case, the flight error statistics for an S RPV between its S and H waypoints were calculated incorrectly by the analysis routine used for the real-time simulation. Thus, the SAINT values for these error statistics were vastly different from the real-time values. These types of conditions were corrected by altering the SAINT model design to reflect actual real-time system performance instead of documented system design.

Definition of Validity

Ideally, the SAINT model should be considered a valid representation of the RPV/DCF simulation if it produces values of system performance measures that are identically equal to those of the real-time simulation. However, since the process is stochastic in nature, the ideal definition

of validity is not applicable. Under the stochastic framework, the model should be considered valid if the distribution governing individual output variables is statistically the same for both the SAINT and real-time simulations.

Although many iterations of the SAINT model can be run, an additional problem was encountered when trying to apply the statistical definition of validity stated above. Only one observation of the real-time simulation output variables was available. Thus, no estimate of the parameters governing the distributions of the real-time simulation output variables could be obtained.

A third definition of validity was developed which satisfies both the constraints stated above and the objectives of this effort. This definition is:

> The SAINT model is considered a valid representation of the RPV/DCF real-time simulation if the observed values of the system performance estimates generated by the real-time simulation could have been obtained, in a probabilistic manner, from the distributions governing the SAINT system performance estimates.

t-test Validation Procedure

The validation analysis of the SAINT model was performed using two separate procedures, depending on the characteristics of the output variable. Cross track and ground speed error are sample mean statistics. The central limit theorem supplies sufficient justification to the assumption that the underlying probability distribution of these variables is normal. Thus, the validation analysis involves a t-test of the real-time value with respect to the SAINT distribution. For purposes of validation, 25 replications of the SAINT simulation were run and a 95% confidence two-sided t-test was performed on these average variables to test the feasibility of obtaining the real-time value from the SAINT distribution. Let X_i denote the value of the SAINT output variable for replication i,i=2 ... 25. Let R denote the corresponding real-time simulation value. Then:

$$X = \text{SAINT sample mean} = \frac{1}{25} \sum_{i=1}^{25} X_i \ ;$$

s = SAINT sample deviation

$$= [\frac{1}{24} \sum_{i=1}^{25} (X_i - \overline{X})^2]^{\frac{1}{2}},$$

and the t statistic is

$$t = \frac{(\overline{X} - R)}{S} .$$

If this t statistic is greater than $t_{25,.975} = 2.06$, the hypothesis that the real-time simulation value is a representative sample from the SAINT distribution is rejected. If not, the hypothesis is accepted and the model is assumed to be valid for the variable in question.

Some clarification of the acceptance and rejection of the hypothesis should be made at this point. If the hypothesis is rejected, the analysis is 95% certain that the underlying distribution of the SAINT variable could not produce the real-time value. However, there is a 5% chance of rejecting the hypothesis when it is true. If the hypothesis is accepted, then the analysis is <u>not</u> 95% certain that the real-time value is not representative of the SAINT distribution. Thus, acceptance does not supply proof that the hypothesis is true; it only indicates that the hypothesis cannot be disproved given the available data. However, since this is the best validation test possible with only one observation of the real-time system output variable available, the acceptance of the hypothesis for an output variable is defined as validating the model for that variable.

Histogram Validation Procedure

The second procedure performed as part of the validation process parallels the t-test for the average statistics. This analysis involves variables that are discrete valued and cannot be assumed to be normal: statistics for operator commands for individual RPVs and command processing statistics, which take values at only discrete five second intervals of time. For each of these variables, a histogram was drawn for the 25 SAINT replication values and the real-time value was indicated on the histogram.

The SAINT model is defined as being valid for these variables if the real-time value lies within the interval whose end points are the minimum and maximum of the SAINT replication values. Thus, the model is defined as being valid if the real-time value is a feasible output of the SAINT simulation.

Performance Measures

The statistics generated by the SAINT simulation are constructed to provide a detailed comparison of the outputs

from the SAINT and real-time simulations. The statistics obtained from the SAINT model duplicate or expand on the system performance statistics generated by the real-time simulation. These statistics, to be defined in the following paragraphs, were determined to be representative of the system performance measures generated by the real-time system and provide a rigorous test for the validity of the SAINT model.

RPV Flight Statistics

The statistics recorded by the SAINT simulation that concern RPV flight and are averaged over RPVs by type (S,E,L) are identical to those computed by the real-time simulation. These statistics are:

1. Average cross track error and ground speed error during the enroute phase for each RPV type

2. Average cross track error and ground speed error during the return phase for each RPV type

3. Average cross track error and ground speed error between S and H for S RPVs

4. Average cross track error and ground speed error at the time the terminal pilot actually took control for S RPVs

5. Average cross track error and ground speed error at H for each RPV type

6. Average cross track error and ground speed error at S for S RPVs

7. Proportion of attritions for each RPV type

8. Proportion of malfunctions for each RPV type

9. Proportion of recoveries for each RPV type

The above statistical categories result in 33 statistical variables that are computed by averaging the appropriate statistic over the RPVs of the appropriate type. However, these statistics do not reflect individual operator differences and thus are not sufficient for the validation procedure. SAINT output statistics also include:

1. Average cross track error and ground speed error during the enroute phase for each RPV

2. Average cross track error and ground speed error during the return phase for each RPV

3. Average cross track error and ground speed error between S and H for each S RPV

These statistics, coupled with those listed above, provide a complete comparison between the SAINT and real-time simulations in terms of RPV flight.

Operator Command Statistics

As with the RPV flight statistics, the real-time summary statistics for operator commands are averaged over RPVs by type. These include:

1. Number of patches attempted per RPV over all mission phases for each RPV type

2. Number of patches successfully completed per RPV over all mission phases for each RPV type

3. Number of velocity commands made per RPV over all mission phases for each RPV type

4. Number of altitude commands made per RPV over all mission phases for each RPV type

5. Number of patches successfully completed per RPV during enroute for each RPV type

6. Number of patches successfully completed per RPV during return for each RPV type

7. Number of reprogram attempts successfully completed for each RPV type

These statistics are computed in the SAINT simulation so that direct comparisons can be made. However, the statistics do not reflect operator differences and thus are not sufficient for validation purposes. To remedy this situation, the SAINT simulation adds the following statistics to the above list:

1. Number of patches attempted during enroute for each RPV

2. Number of patches attempted during return for each RPV

3. Number of patches attempted between S and H for each S RPV

4. Number of velocity changes during enroute for each RPV

5. Number of velocity changes during return for each RPV

6. Number of patches rejected for each RPV

These statistics provide a complete comparison between the SAINT and real-time simulations in terms of number of operator commands initiated.

Command Processing Statistics

The RPV/DCF real-time simulation maintains statistics on the proportion of RPVs of each type that execute the pop-up maneuver prior to H and execute the pop-down maneuver within 120 seconds of handback. Since these statistics do not differentiate between RPVs and since they only reflect gross timing averages, they were found to be inadequate for validation purposes. The SAINT simulation records timing values for individual RPVs. These values are:

1. The time of processing of the pop-up maneuver for each RPV

2. The time of processing of the handover-prepare operation for each RPV

3. The time of terminal pilot or pseudo-pilot handover-accept command processing for each RPV

4. The time of terminal or pseudo-pilot handback command processing for each RPV

5. The time of processing of the pop-down maneuver for each RPV

6. The time of arrival at the first major waypoint of each RPV

These statistics provide a complete comparison between the SAINT and real-time simulations in terms of handover-handback timing values.

Analysis of Results

For each statistic type, the results of the validation process are presented in tabular form, the values obtained

summarized, and any discrepancies between the SAINT and real-time statistics discussed. The discrepancies arise from the fact that relatively simple moderator functions were employed to reflect operator performance. The discussion of these differences as they relate to output measures focuses on the moderator functions that require improvement to more accurately represent actual operator performance. The development of improved moderator functions was not within the scope of this effort. However, the results obtained were more than adequate in satisfying the project objectives.

RPV Flight Statistics

The t-test analysis presented previously has been applied to the RPV flight statistics that are averaged over RPVs by type. The results of this analysis are given in Table VI. For each variable, the table presents the sample mean and standard deviation of the SAINT output values, the 95% upper and lower confidence limits for the observations, the real-time simulation value, the t-statistic for this test, and the results of the test ("yes" for accepting the model as being valid for this statistic or "no" for rejecting the validity of the model for this statistic). From this table, it can be seen that the SAINT model has been determined to be valid for 30 of the 33 average statistics. The three statistics that are rejected for validity are the cross track error during enroute for E RPVs, the cross track error during return for L RPVs, and the ground speed error during return for E RPVs.

To more fully define these three statistics, histograms of the SAINT replicated values were prepared, with the real-time simulation value indicated.[2] These histograms appear in Figures 17, 18 and 19, respectively. The first condition that should be noticed when analyzing these histograms is that the real-time value does not appear to be significantly different from the SAINT values. Thus, the rejection of validity for these variables may simply be due to the randomness in the process. However, there may be operator-oriented reasons behind these rejections. The SAINT model assumes the operators treat E and L RPVs identically. Perhaps, unconsciously or consciously, the operators have a preferential treatment of one over the other (it is known that S RPVs are treated differently in some situations). This is one area where a deeper analysis of human characteristics might improve the moderator functions included in the model.

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[2]The real-time simulation value is indicated on the histograms presented by a "$\square$"

TABLE VI

t-TEST RESULTS FOR RPV FLIGHT STATISTICS BY RPV TYPE

Variable Name	RPV Type	SAINT Sample Mean	SAINT Sample Standard Deviation	95% UCL for observation	95% LCL for observation	Real Time Value	t-stat	Accept?
Cross Track Error During Enroute	S	316.11	33.42	384.96	247.26	283.81	-.97	yes
Cross Track Error During Enroute	E	325.09	21.19	368.74	281.44	370.15	2.13	no
Cross Track Error During Enroute	L	301.40	31.38	366.04	236.76	325.58	.77	yes
Ground Speed Error During Enroute	S	131.83	18.25	169.43	94.23	105.06	-1.47	yes
Ground Speed Error During Enroute	E	121.80	18.13	159.15	84.45	149.39	1.52	yes
Ground Speed Error During Enroute	L	133.21	17.20	168.64	97.78	126.34	-.40	yes

Table VI continued

Variable Name	RPV Type	SAINT Sample Mean	SAINT Sample Standard Deviation	95% UCL for observation	95% LCL for observation	Real Time Value	t-stat	Accept?
Cross Track Error at H	S	432.52	151.26	744.12	120.92	281.56	-1.00	yes
Cross Track Error at H	E	350.64	126.56	611.35	89.93	534.98	1.46	yes
Cross Track Error at H	L	522.47	103.27	735.21	309.73	539.30	.16	yes
Ground Speed Error at H	S	263.22	98.97	467.10	59.34	432.11	1.71	yes
Ground Speed Error at H	E	340.98	107.50	562.43	119.53	286.10	-.51	yes
Ground Speed Error at H	L	334.54	124.89	591.81	77.27	150.57	-1.48	yes
Cross Track Error During Return	S	316.33	26.37	370.65	262.01	312.15	-.16	yes
Cross Track Error During Return	E	333.90	21.18	377.53	290.27	376.29	2.00	yes

Table VI continued

Variable Name	RPV Type	SAINT Sample Mean	SAINT Sample Standard Deviation	95% UCL for observation	95% LCL for observation	Real Time Value	t-stat	Accept?
Cross Track Error During Return	L	330.65	26.64	385.53	275.77	268.31	-2.34	no
Ground Speed Error During Return	S	200.45	34.25	271.01	129.89	207.88	.22	yes
Ground Speed Error During Return	E	178.32	26.88	233.69	122.95	235.42	2.12	no
Ground Speed Error During Return	L	239.98	53.32	349.82	130.14	163.13	-1.44	yes
Cross Track Error From S to H	S	396.60	124.49	653.05	140.15	242.66	-1.24	yes
Ground Speed Error From S to H	S	266.13	80.03	430.99	101.27	341.09	.94	yes
Cross Track Error at S	S	352.85	107.88	575.08	130.62	246.30	-.99	yes

Table VI continued

Variable Name	RPV Type	SAINT Sample Mean	SAINT Sample Standard Deviation	95% UCL for observation	95% LCL for observation	Real Time Value	t-stat	Accept?
Ground Speed Error at S	S	284.79	82.59	454.92	114.66	178.45	-1.29	yes
Cross Track Error From H for Pilot	S	432.52	151.26	744.12	120.92	230.19	-1.34	yes
Ground Speed Error From H for Pilot	S	5598.57	294.92	6206.11	4991.03	5800.07	.68	yes
Proportion of Attritions	S	0.00	0.00	0.00	0.00	0.00	--	yes
Proportion of Attritions	E	0.00	0.00	0.00	0.00	0.00	--	yes
Proportion of Attritions	L	0.17	0.00	0.17	0.17	0.17	--	yes
Proportion of Malfunctions	S	0.00	0.00	0.00	0.00	0.00	--	yes
Proportion of Malfunctions	E	0.00	0.00	0.00	0.00	0.00	--	yes

Table VI continued

Variable Name	RPV Type	SAINT Sample Mean	SAINT Sample Standard Deviation	95% UCL for observation	95% LCL for observation	Real Time Value	t-stat	Accept?
Proportion of Malfunctions	L	0.00	0.00	0,00	0.00	0.00	--	yes
Proportion of Recoveries	S	1.00	0.00	1.00	1.00	1.00	--	yes
Proportion of Recoveries	E	1.00	0.00	1.00	1.00	1.00	--	yes
Proportion of Recoveries	L	0.83	0.00	0.83	0.83	0.83	--	yes

HISTOGRAM FOR

CROSS TRACK ERROR DURING ENROUTE FOR E RPVS

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 50	0	0.000
50 - 100	0	0.000
100 - 150	0	0.000
150 - 200	0	0.000
200 - 250	0	0.000
250 - 300	4	.160
300 - 350	19	.760
350 - 400	2	.080
400 - 450	0	0.000
450 - 500	0	0.000
500 - 550	0	0.000
550 - 600	0	0.000
600 - 650	0	0.000
650 - 700	0	0.000
700 - 750	0	0.000
750 - 800	0	0.000
800 - 850	0	0.000
850 - 900	0	0.000
900 - 950	0	0.000
950 - 1000	0	0.000
1000 - 1050	0	0.000
1050 - 1100	0	0.000
1100 - 1150	0	0.000
1150 - 1200	0	0.000
1200 - 1250	0	0.000
1250 - 1300	0	0.000
1300 - 1350	0	0.000
1350 - 1400	0	0.000
1400 - 1450	0	0.000
1450 - 1500	0	0.000

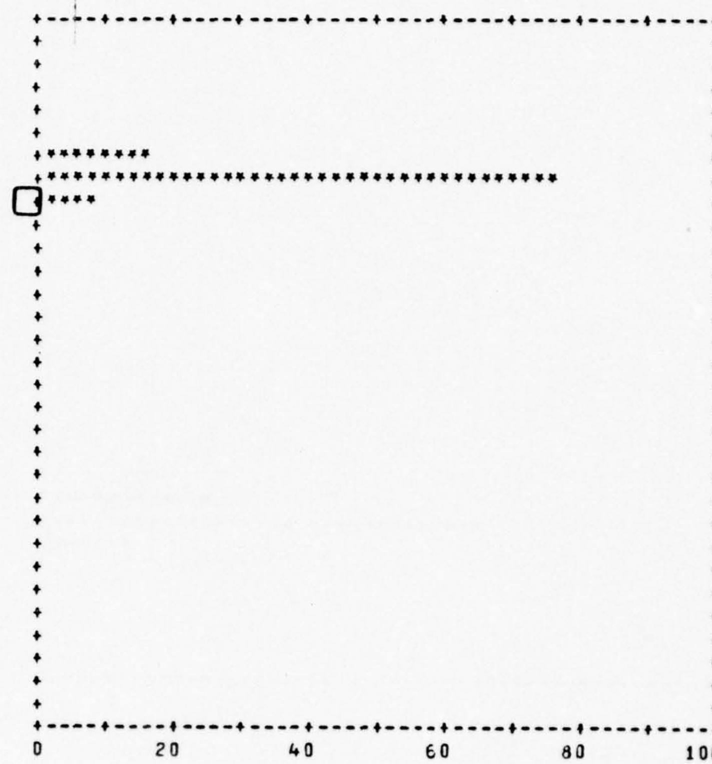

Figure 17. Histogram for Cross Track Error During Enroute for E RPVS.

HISTOGRAM FOR

CROSS TRACK ERROR DURING RETURN FOR L RPVS

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 50	0	0.000
50 - 100	0	0.000
100 - 150	0	0.000
150 - 200	0	0.000
200 - 250	0	0.000
250 - 300	3	.120
300 - 350	16	.640
350 - 400	6	.240
400 - 450	0	0.000
450 - 500	0	0.000
500 - 550	0	0.000
550 - 600	0	0.000
600 - 650	0	0.000
650 - 700	0	0.000
700 - 750	0	0.000
750 - 800	0	0.000
800 - 850	0	0.000
850 - 900	0	0.000
900 - 950	0	0.000
950 - 1000	0	0.000
1000 - 1050	0	0.000
1050 - 1100	0	0.000
1100 - 1150	0	0.000
1150 - 1200	0	0.000
1200 - 1250	0	0.000
1250 - 1300	0	0.000
1300 - 1350	0	0.000
1350 - 1400	0	0.000
1400 - 1450	0	0.000
1450 - 1500	0	0.000

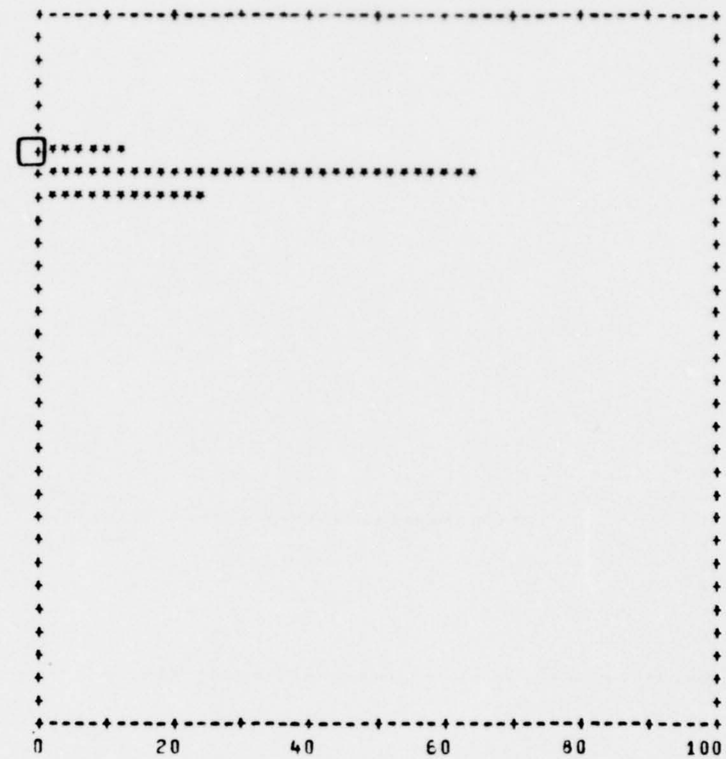

Figure 18. Histogram for Cross Track Error During Return for L RPVs.

HISTOGRAM FOR

GROUND SPEED ERROR DURING RETURN FOR E RPVS

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 50	0	0.000
50 - 100	0	0.000
100 - 150	5	.200
150 - 200	14	.560
200 - 250	6	.240
250 - 300	0	0.000
300 - 350	0	0.000
350 - 400	0	0.000
400 - 450	0	0.000
450 - 500	0	0.000
500 - 550	0	0.000
550 - 600	0	0.000
600 - 650	0	0.000
650 - 700	0	0.000
700 - 750	0	0.000
750 - 800	0	0.000
800 - 850	0	0.000
850 - 900	0	0.000
900 - 950	0	0.000
950 - 1000	0	0.000
1000 - 1050	0	0.000
1050 - 1100	0	0.000
1100 - 1150	0	0.000
1150 - 1200	0	0.000
1200 - 1250	0	0.000
1250 - 1300	0	0.000
1300 - 1350	0	0.000
1350 - 1400	0	0.000
1400 - 1450	0	0.000
1450 - 1500	0	0.000

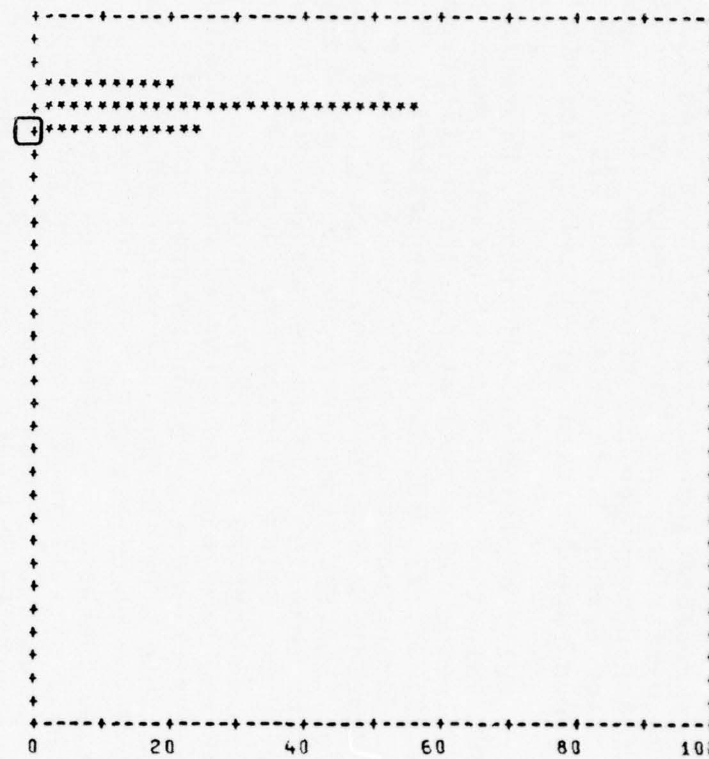

Figure 19. Histogram for Ground Speed Error During Return for E RPVs.

The t-test analysis has also been applied to the mission performance statistics for flight path error of individual RPVs. The results of this analysis are presented in Table VII. These results indicate that the SAINT model is a valid representation of the real-time simulation for 69 of the 74 variables. The five rejected are the ground speed error during enroute for RPV 5, the ground speed and cross track errors during return for RPV 7, and the cross track and ground speed errors during return for RPV 14.

To more fully explain the rejections, histograms of the SAINT values of the rejected variables were generated with the real-time value indicated. These histograms appear in Figures 20, 21, 22, 23, and 24, respectively. The ground speed error during enroute for RPV 5 may be higher in the real-time simulation due to randomness or due to some differentiation of this RPV from others by the controlling operator. The other four rejected statistics seem to display some consistency. The SAINT operator provides lower cross track and ground speed errors for RPV 7 on return. This seems to point to the fact that operator 4, who is modeled as treating all RPVs identically on return, actually has less concern with his S RPV during the return phase. Also, SAINT operator 2 seems to direct RPV 14 for return better than the real-time operator. Operators 3 and 4 are modeled as treating their extra RPVs differently on return; perhaps so should operator 2. These results indicate additional areas that should be analyzed in the development of moderator functions.

Operator Command Statistics

Operator command statistics are of two types: those averaged over RPVs by type and those for individual RPVs. The t-test analysis has been applied to those operator command statistics averaged over RPVs by type. The results of this analysis appear in Table VIII. As these results indicate, the SAINT model is a valid representation of the real-time simulation for all 18 variables analyzed.

The operator command statistics for individual RPVs are tested for validation based on the real-time value in relation to the histogram of the SAINT replication values. For each variable, the following test is made: If the real-time value lies within the minimum and maximum of the SAINT values, the model is assumed valid. The results of this analysis are presented in Table IX. The histograms for selected operator command statistics appear in Appendix I.

TABLE VII

t-TEST RESULTS FOR INDIVIDUAL RPV FLIGHT PATH ERROR STATISTICS

Variable Name	RPV Number	SAINT Sample Mean	SAINT Sample Standard Deviation	95% UCL for observation	95% LCL for observation	Real Time Value	t-stat	Accept?
Cross Track Error During Enroute	1	435	61	561	309	548	1.85	yes
Ground Speed Error During Enroute	1	114	26	169	60	119	.17	yes
Cross Track Error During Return	1	393	46	487	299	327	-1.44	yes
Ground Speed Error During Return	1	165	32	232	99	225	1.84	yes
Cross Track Error During Enroute	2	614	57	732	496	683	1.20	yes
Ground Speed Error During Enroute	2	128	38	207	48	145	.46	yes

Table VII continued

Variable Name	RPV Number	SAINT Sample Mean	SAINT Sample Standard Deviation	95% UCL for observation	95% LCL for observation	Real Time Value	t-stat	Accept?
Cross Track Error During Return	2	590	41	674	507	532	-1.43	yes
Ground Speed Error During Return	2	233	75	388	79	268	.46	yes
Cross Track Error During Enroute	3	366	122	616	115	396	.25	yes
Ground Speed Error During Enroute	3	201	94	395	7	185	-.17	yes
Cross Track Error During Return	3	343	127	605	81	244	-.78	yes
Ground Speed Error During Return	3	483	254	1007	-41	212	-1.07	yes
Cross Track Error During Enroute	4	297	54	409	185	292	-.10	yes

Table VII continued

Variable Name	RPV Number	SAINT Sample Mean	SAINT Sample Standard Deviation	95% UCL for observation	95% LCL for observation	Real Time Value	t-stat	Accept?
Ground Speed Error During Enroute	4	106	25	157	54	120	.58	yes
Cross Track Error During Return	4	348	74	500	196	315	-.45	yes
Ground Speed Error During Return	4	218	59	340	96	207	-.19	yes
Cross Track Error During Enroute	5	173	37	249	98	247	2.01	yes
Ground Speed Error During Enroute	5	109	29	168	50	226	4.09	no
Cross Track Error During Return	5	199	44	289	110	248	1.12	yes
Ground Speed Error During Return	5	144	34	214	74	142	-.05	yes

Table VII continued

Variable Name	RPV Number	SAINT Sample Mean	SAINT Sample Standard Deviation	95% UCL for observation	95% LCL for observation	Real Time Value	t-stat	Accept?
Cross Track Error During Enroute	6	214	40	297	131	277	1.57	yes
Ground Speed Error During Enroute	6	107	23	153	60	119	.54	yes
Cross Track Error During Return	6	242	38	320	164	183	-1.56	yes
Ground Speed Error During Return	6	151	49	253	50	134	-.36	yes
Cross Track Error During Enroute	7	172	33	240	103	142	-.89	yes
Ground Speed Error During Enroute	7	89	18	127	51	62	-1.45	yes
Cross Track Error During Return	7	197	57	314	79	388	3.35	no

Table VII continued

Variable Name	RPV Number	SAINT Sample Mean	SAINT Sample Standard Deviation	95% UCL for observation	95% LCL for observation	Real Time Value	t-stat	Accept?
Ground Speed Error During Return	7	105	26	158	51	187	3.17	no
Cross Track Error During Enroute	8	160	37	237	84	162	.05	yes
Ground Speed Error During Enroute	8	126	32	193	59	97	-.90	yes
Cross Track Error During Return	8	185	36	259	110	185	.01	yes
Ground Speed Error During Return	8	151	57	270	33	107	-.77	yes
Cross Track Error During Enroute	9	438	54	549	327	522	1.57	yes
Ground Speed Error During Enroute	9	150	35	222	78	133	-.49	yes

Table VII continued

Variable Name	RPV Number	SAINT Sample Mean	SAINT Sample Standard Deviation	95% UCL for observation	95% LCL for observation	Real Time Value	t-stat	Accept?
Cross Track Error During Return	9	531	87	711	351	389	-1.63	yes
Ground Speed Error During Return	9	299	100	505	93	238	-.61	yes
Cross Track Error During Enroute	10	221	73	371	71	87	-1.84	yes
Ground Speed Error During Enroute	10	108	44	198	18	75	-.76	yes
Cross Track Error During Return	10	251	91	438	64	239	-.13	yes
Ground Speed Error During Return	10	179	84	352	5	221	.50	yes
Cross Track Error During Enroute	11	210	72	358	63	283	1.02	yes

Table VII continued

Variable Name	RPV Number	SAINT Sample Mean	SAINT Sample Standard Deviation	95% UCL for observation	95% LCL for observation	Real Time Value	t-stat	Accept?
Ground Speed Error During Enroute	11	106	47	201	10	108	.05	yes
Cross Track Error During Return	11	273	63	404	143	402	2.03	yes
Ground Speed Error During Return	11	191	92	381	0	347	1.69	yes
Cross Track Error During Enroute	12	216	70	359	73	196	-.29	yes
Ground Speed Error During Enroute	12	123	49	223	22	117	-.11	yes
Cross Track Error During Return	12	275	68	415	134	361	1.27	yes
Ground Speed Error During Return	12	174	77	332	16	140	-.44	yes

Table VII continued

Variable Name	RPV Number	SAINT Sample Mean	SAINT Sample Standard Deviation	95% UCL for observation	95% LCL for observation	Real Time Value	t-stat	Accept?
Cross Track Error During Enroute	13	453	87	632	274	351	-1.18	yes
Ground Speed Error During Enroute	13	240	68	381	99	148	-1.34	yes
Cross Track Error During Return	13	390	56	505	276	293	-1.75	yes
Ground Speed Error During Return	13	333	149	640	26	198	-.91	yes
Cross Track Error During Enroute	14	465	79	628	302	477	.15	yes
Ground Speed Error During Enroute	14	138	37	215	62	170	.85	yes

Table VII continued

Variable Name	RPV Number	SAINT Sample Mean	SAINT Sample Standard Deviation	95% UCL for observation	95% LCL for observation	Real Time Value	t-stat	Accept?
Cross Track Error During Return	14	420	35	491	348	516	2.78	no
Ground Speed Error During Return	14	169	36	243	96	313	4.03	no
Cross Track Error During Enroute	15	303	54	414	192	315	.22	yes
Ground Speed Error During Enroute	15	123	29	183	64	89	-1.20	yes
Cross Track Error During Return	15	335	60	457	212	228	-1.79	yes
Ground Speed Error During Return	15	180	77	338	23	140	-.53	yes
Cross Track Error During Enroute	16	269	82	438	100	247	-.27	yes

Table VII continued

Variable Name	RPV Number	SAINT Sample Mean	SAINT Sample Standard Deviation	95% UCL for observation	95% LCL for observation	Real Time Value	t-stat	Accept?
Ground Speed Error During Enroute	16	92	22	138	46	115	1.03	yes
Cross Track Error During Return	16	255	46	351	160	206	-1.06	yes
Ground Speed Error During Return	16	149	58	269	29	113	-.62	yes
Cross Track Error Between S and H	1	571	221	1027	116	165	-1.84	yes
Ground Speed Error Between S and H	1	267	190	658	-125	497	1.21	yes
Cross Track Error Between S and H	4	585	419	1448	-278	442	-.34	yes
Ground Speed Error Between S and H	4	240	124	496	-17	307	.54	yes

Table VII continued

Variable Name	RPV Number	SAINT Sample Mean	SAINT Sample Standard Deviation	95% UCL for observation	95% LCL for observation	Real Time Value	t-stat	Accept?
Cross Track Error Between S and H	7	223	160	553	-107	201	-.14	yes
Ground Speed Error Between S and H	7	276	224	738	-185	287	.05	yes
Cross Track Error Between S and H	10	148	78	309	-14	135	-.16	yes
Ground Speed Error Between S and H	10	303	166	646	-40	202	-.61	yes
Cross Track Error Between S and H	13	454	307	1087	-180	270	-.60	yes
Ground Speed Error Between S and H	13	242	174	600	-117	417	1.01	yes

HISTOGRAM FOR

GROUND SPEED ERROR DURING ENROUTE FOR RPV 5

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 50	0	0.000
50 - 100	10	.400
100 - 150	13	.520
150 - 200	2	.080
200 - 250	0	0.000
250 - 300	0	0.000
300 - 350	0	0.000
350 - 400	0	0.000
400 - 450	0	0.000
450 - 500	0	0.000
500 - 550	0	0.000
550 - 600	0	0.000
600 - 650	0	0.000
650 - 700	0	0.000
700 - 750	0	0.000
750 - 800	0	0.000
800 - 850	0	0.000
850 - 900	0	0.000
900 - 950	0	0.000
950 - 1000	0	0.000
1000 - 1050	0	0.000
1050 - 1100	0	0.000
1100 - 1150	0	0.000
1150 - 1200	0	0.000
1200 - 1250	0	0.000
1250 - 1300	0	0.000
1300 - 1350	0	0.000
1350 - 1400	0	0.000
1400 - 1450	0	0.000
1450 - 1500	0	0.000

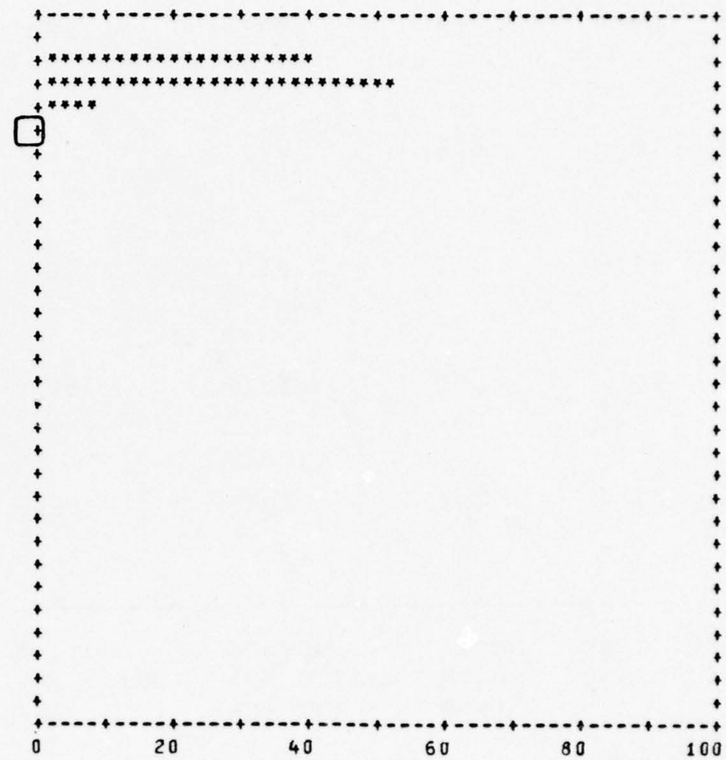

Figure 20. Histogram for Ground Speed Error During Enroute for RPV 5.

HISTOGRAM FOR

CROSS TRACK ERROR DURING RETURN FOR RPV 7

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 50	0	0.000
50 - 100	0	0.000
100 - 150	5	.200
150 - 200	10	.400
200 - 250	7	.280
250 - 300	2	.080
300 - 350	0	0.000
350 - 400	1	.040
400 - 450	0	0.000
450 - 500	0	0.000
500 - 550	0	0.000
550 - 600	0	0.000
600 - 650	0	0.000
650 - 700	0	0.000
700 - 750	0	0.000
750 - 800	0	0.000
800 - 850	0	0.000
850 - 900	0	0.000
900 - 950	0	0.000
950 - 1000	0	0.000
1000 - 1050	0	0.000
1050 - 1100	0	0.000
1100 - 1150	0	0.000
1150 - 1200	0	0.000
1200 - 1250	0	0.000
1250 - 1300	0	0.000
1300 - 1350	0	0.000
1350 - 1400	0	0.000
1400 - 1450	0	0.000
1450 - 1500	0	0.000

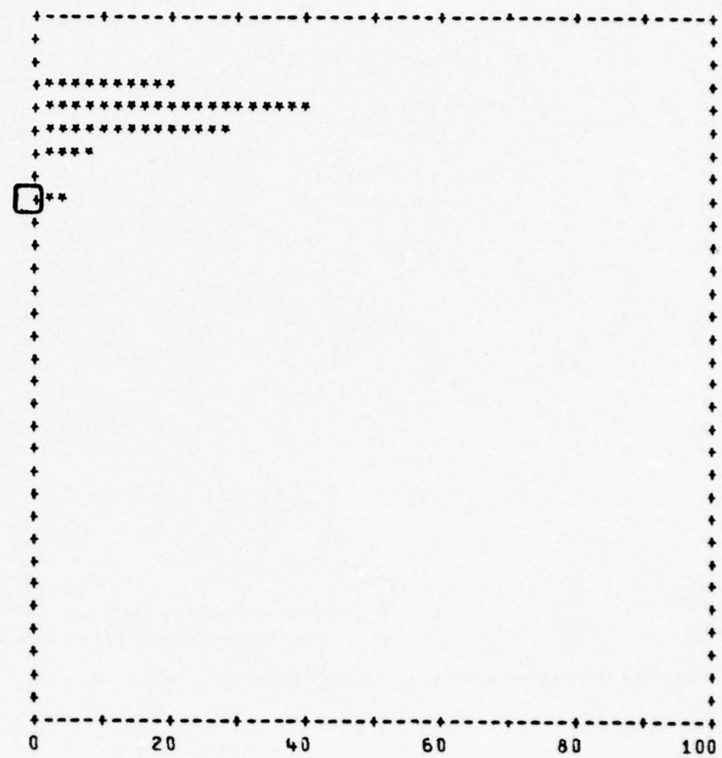

Figure 21. Histogram for Cross Track Error During Return for RPV 7.

HISTOGRAM FOR

GROUND SPEED ERROR DURING RETURN FOR RPV 7

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 50	0	0.000
50 - 100	11	.440
100 - 150	12	.480
150 - 200	2	.080
200 - 250	0	0.000
250 - 300	0	0.000
300 - 350	0	0.000
350 - 400	0	0.000
400 - 450	0	0.000
450 - 500	0	0.000
500 - 550	0	0.000
550 - 600	0	0.000
600 - 650	0	0.000
650 - 700	0	0.000
700 - 750	0	0.000
750 - 800	0	0.000
800 - 850	0	0.000
850 - 900	0	0.000
900 - 950	0	0.000
950 - 1000	0	0.000
1000 - 1050	0	0.000
1050 - 1100	0	0.000
1100 - 1150	0	0.000
1150 - 1200	0	0.000
1200 - 1250	0	0.000
1250 - 1300	0	0.000
1300 - 1350	0	0.000
1350 - 1400	0	0.000
1400 - 1450	0	0.000
1450 - 1500	0	0.000

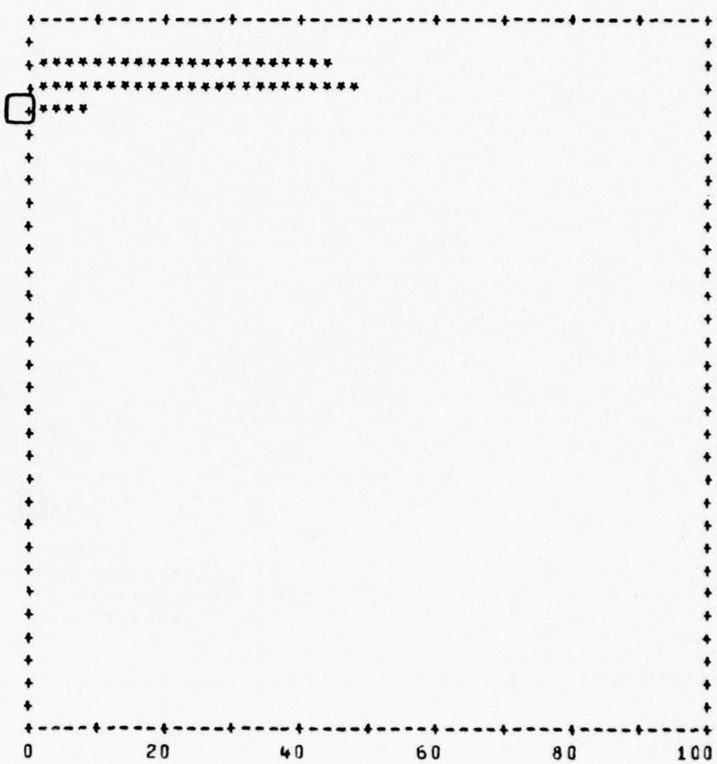

Figure 22. Histogram for Ground Speed Error During Return for RPV 7.

HISTOGRAM FOR

CROSS TRACK ERROR DURING RETURN FOR RPV 14

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 50	0	0.000
50 - 100	0	0.000
100 - 150	0	0.000
150 - 200	0	0.000
200 - 250	0	0.000
250 - 300	0	0.000
300 - 350	0	0.000
350 - 400	7	.280
400 - 450	13	.520
450 - 500	5	.200
500 - 550	0	0.000
550 - 600	0	0.000
600 - 650	0	0.000
650 - 700	0	0.000
700 - 750	0	0.000
750 - 800	0	0.000
800 - 850	0	0.000
850 - 900	0	0.000
900 - 950	0	0.000
950 - 1000	0	0.000
1000 - 1050	0	0.000
1050 - 1100	0	0.000
1100 - 1150	0	0.000
1150 - 1200	0	0.000
1200 - 1250	0	0.000
1250 - 1300	0	0.000
1300 - 1350	0	0.000
1350 - 1400	0	0.000
1400 - 1450	0	0.000
1450 - 1500	0	0.000

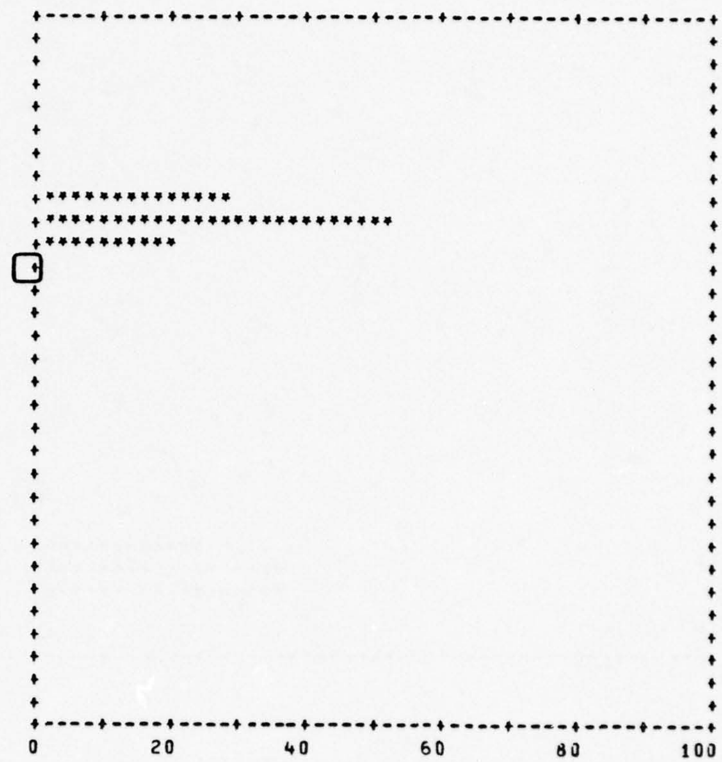

Figure 23. Histogram for Cross Track Error During Return for RPV 14.

HISTOGRAM FOR

GROUND SPEED ERROR DURING RETURN FOR RPV 14

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 50	0	0.000
50 - 100	0	0.000
100 - 150	9	.360
150 - 200	9	.360
200 - 250	7	.280
250 - 300	0	0.000
300 - 350	0	0.000
350 - 400	0	0.000
400 - 450	0	0.000
450 - 500	0	0.000
500 - 550	0	0.000
550 - 600	0	0.000
600 - 650	0	0.000
650 - 700	0	0.000
700 - 750	0	0.000
750 - 800	0	0.000
800 - 850	0	0.000
850 - 900	0	0.000
900 - 950	0	0.000
950 - 1000	0	0.000
1000 - 1050	0	0.000
1050 - 1100	0	0.000
1100 - 1150	0	0.000
1150 - 1200	0	0.000
1200 - 1250	0	0.000
1250 - 1300	0	0.000
1300 - 1350	0	0.000
1350 - 1400	0	0.000
1400 - 1450	0	0.000
1450 - 1500	0	0.000

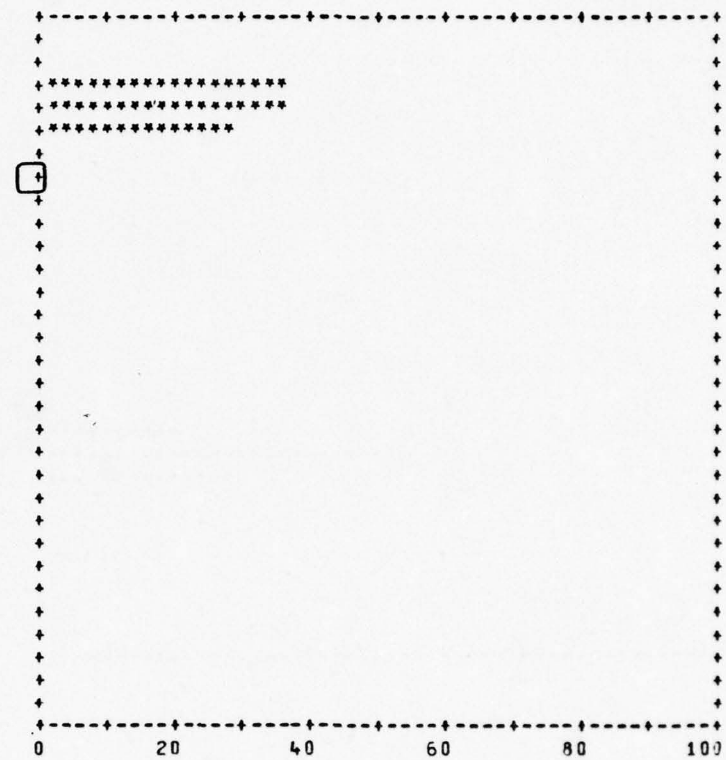

Figure 24. Histogram for Ground Speed Error During Return for RPV 14.

TABLE VIII

t-TEST RESULTS FOR OPERATOR COMMAND STATISTICS BY RPV TYPE

Variable Name	RPV Type	SAINT Sample Mean	SAINT Sample Standard Deviation	95% Ucl for observation	95% LCL for observation	Real Time Value	t-stat	Accept?
Number of Altitude Changes Per RPV	S	2.00	0.00	2.00	2.00	2.00	--	yes
Number of Altitude Changes Per RPV	E	2.00	0.00	2.00	2.00	2.00	--	yes
Number of Altitude Changes Per RPV	L	1.83	0.00	1.83	1.83	1.83	--	yes
Number of Patches Attempted Per RPV	S	34.80	2.72	40.40	29.20	35.80	.37	yes
Number of Patches Attempted Per RPV	E	29.74	2.38	34.64	24.84	26.80	-1.24	yes
Number of Patches Attempted Per RPV	L	33.73	2.32	38.51	28.95	32.50	-.53	yes

Table VIII continued

Variable Name	RPV Type	SAINT Sample Mean	SAINT Sample Standard Deviation	95% UCL for observation	95% LCL for observation	Real Time Value	t-stat	Accept?
Number of Patches Completed Per RPV	S	32.74	2.47	37.83	27.65	33.80	.43	yes
Number of Patches Completed Per RPV	E	28.26	2.20	32.79	23.73	25.20	-1.40	yes
Number of Patches Completed Per RPV	L	31.29	2.24	35.90	26.68	31.83	.24	yes
Number of Velocity Changes Per RPV	S	5.93	.97	7.93	3.93	6.90	.90	yes
Number of Velocity Changes Per RPV	E	8.38	1.45	11.37	5.39	7.00	-.95	yes
Number of Velocity Changes Per RPV	L	8.60	1.11	10.89	6.31	6.50	-1.89	yes
Attempted Patches Per RPV, Enroute	S	13.01	1.44	15.98	10.04	12.20	-.56	yes

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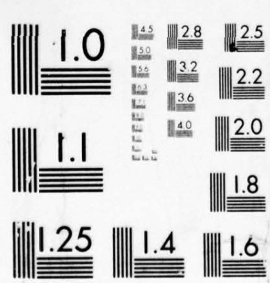

MICROCOPY RESOLUTION TEST CHART
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Table VIII continued

Variable Name	RPV Type	SAINT Sample Mean	SAINT Sample Standard Deviation	95% UCL for observation	95% LCL for observation	Real Time Value	t-stat	Accept?
Attempted Patches Per RPV, Enroute	E	11.78	1.45	14.77	8.79	10.60	-.81	yes
Attempted Patches Per RPV, Enroute	L	14.57	1.08	16.79	12.35	13.50	-.99	yes
Attempted Patches Per RPV, Return	S	20.92	1.75	24.52	17.32	22.00	.62	yes
Attempted Patches Per RPV, Return	E	17.90	1.95	21.92	13.88	16.20	-.87	yes
Attempted Patches Per RPV, Return	L	19.13	1.66	22.55	15.71	19.00	-.08	yes

TABLE IX

RESULTS FOR OPERATOR COMMAND STATISTICS

Statistic	RPV Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Number of Patches, Enroute	19.0[1] 18[2] yes[3]	7.9 8 yes	1.4 3 yes	23.4 21 yes	22.8 20 yes	25.6 20 yes	15.8 13 yes	16.9 16 yes	24.0 26 yes	1.9 1 yes	2.0 2 yes	1.8 1 yes	3.1 6 yes	6.3 5 yes	19.6 19 yes	12.3 9 yes
Number of Patches, Return	27.8 21 yes	9.7 9 yes	0.6 2 yes	40.5 48 yes	41.5 39 yes	37.7 47 yes	24.5 27 yes	24.3 21 yes	24.7 24 yes	2.9 3 yes	2.5 1 yes	2.6 3 yes	2.7 6 no	7.4 5 yes	21.2 20 yes	16.0 17 yes
Number of Patches Between S,H	0.1 1 yes	- - -	- - -	0.4 0 yes	- - -	- - -	1.0 3 yes	- - -	- - -	0.6 1 yes	- - -	- - -	0.0 0 yes	- - -	- - -	- - -
Number of Patch Rejections	3.2 2 yes	0.9 2 yes	0.1 0 yes	4.9 4 yes	4.2 2 yes	8.3 1 yes	1.2 3 yes	1.6 4 yes	1.5 1 yes	0.9 0 yes	0.2 0 yes	0.2 0 yes	0.0 1 yes	0.4 0 yes	1.3 2 yes	3.4 0 yes
Number of Velocity Changes, Enroute	2.8 4 yes	5.4 5 yes	7.0 4 yes	1.8 1 yes	6.4 3 yes	6.0 7 yes	1.0 2 yes	5.3 2 yes	5.2 7 yes	0.8 2 yes	5.7 8 yes	4.8 3 yes	1.1 1 yes	6.2 7 yes	6.3 3 no	5.7 4 yes

Table IX continued

Statistic	RPV Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Number of Velocity Changes, Return	7.6 7 yes	0.7 0 yes	0.3 0 yes	2.8 3 yes	5.2 5 yes	5.5 3 yes	3.6 5 yes	4.2 3 yes	3.7 3 yes	3.6 4 yes	2.8 1 yes	3.0 2 yes	4.6 5 yes	0.1 1 yes	0.1 0 yes	3.8 2 yes

[1]SAINT Sample Mean from 25 Replications
[2]Real-time value
[3]Accept Hypothesis of Histogram Test?

Discrepancies for command statistics occur in only two of the 85 variables: the number of patches on return for RPV 13 and the number of velocity changes on enroute for RPV 15. The histograms for these statistics appear in Figures 25 and 26. These differences could be due to randomness, to the patching criteria employed, or to the manner in which the operators determine the new velocity for an ETA prompted velocity change. These areas require further analysis as they relate to moderator functions.

<u>Command Processing Statistics</u>

A histogram analysis was performed for the command processing statistics collected. The results of this analysis appear in Table X. Histograms for selected command processing statistics appear in Appendix II. These results show that in all but 6 of the 71 cases, the model is valid. The exceptions are:

1. Time of pop-down for RPV 10

2. Time of pop-down for RPV 12

3. Time of pop-down for RPV 15

4. Time of handover-prepare for RPV 12

5. Time handover-accept for RPV 15

6. Time of handback for RPV 10

The histograms for these statistics are shown in Figures 27 through 32. The histograms indicate that RPV 10 is handed-back to the enroute recovery operator and popped-down sooner by the real-time operators than the SAINT operators. Although the deviations between the two are not large, they do point to the need for an analysis of terminal flight by the pilots, i.e., when and why does the pilot release control of the RPV. This could be random condition or one that has a relationship, for example, to lateral deviation of the RPV at the time of terminal pilot control. RPV 12 and RPV 15 are both popped-down later by the real-time operators than by the SAINT operators. This indicates that the perception of a required pop-down may not be as immediate as assumed in the SAINT model. Also, the handover-prepare for RPV 12 and handover-accept for RPV 15 are actually performed later than predicted by the SAINT model. Thus, while the time values employed by the SAINT operators to determine the time of operations generally produce timing statistics that agree with the real-time values, there are

HISTOGRAM FOR

NUMBER OF PATCHES, RETURN FOR RPV 13

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	2	.080
2 - 3	17	.680
4 - 5	6	.240
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	0	0.000
22 - 23	0	0.000
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000

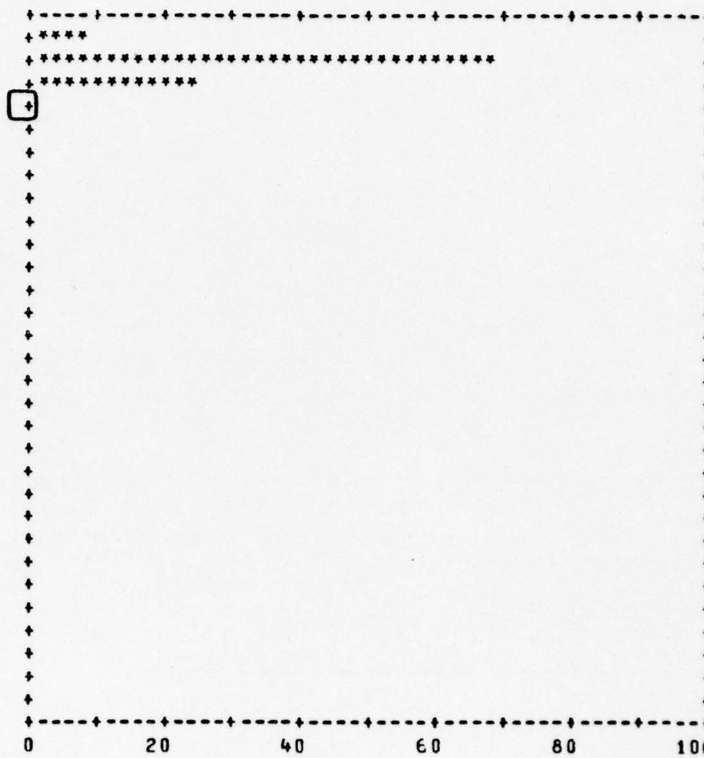


Figure 25. Histogram for Number of Patches During Return for RPV 13.

HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, ENROUTE FOR RPV 15

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	0	0.000
2 - 2	0	0.000
3 - 3	0	0.000
4 - 4	4	.160
5 - 5	8	.320
6 - 6	2	.030
7 - 7	4	.160
8 - 8	4	.160
9 - 9	2	.080
10 - 10	0	0.000
11 - 11	1	.040
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000

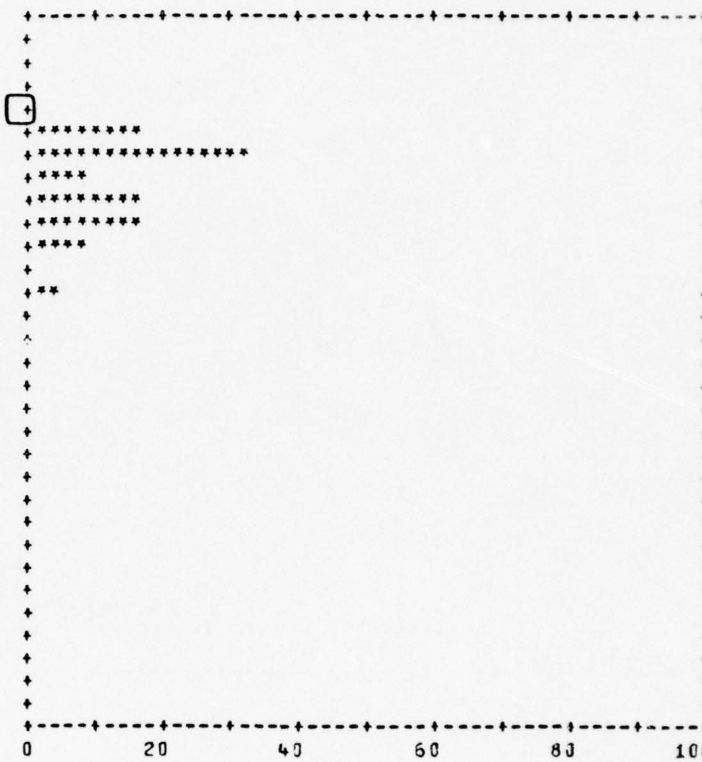


Figure 26. Histogram for Number of Velocity Changes During Enroute for RPV 15.

TABLE X

RESULTS FOR COMMAND PROCESSING STATISTICS

	RPV Number															
Statistic	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Time of	1802[1]	1946	2034	1866	2008	2112	2132	2273	2376	2322	2389	2499	2359	2495	2600	2724
Pop-up	1800[2]	1930	2045	1865	2015	2115	2130	2275	2380	2325	2380	2505	2385	2505	2640	2730
Maneuver	yes[3]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Time of	1979	1984	-	2041	2049	2147	2331	2317	2423	2506	2494	2604	2556	2538	2641	2769
Pop-Down	1965	1970	-	2035	2055	2155	2310	2325	2430	2480	2500	2645	2540	2540	2680	2765
Maneuver	yes	yes	-	yes	yes	yes	yes	yes	yes	no	yes	no	yes	yes	no	yes
Time of	1830	1957	2052	1950	2024	2122	2161	2290	2390	2354	2464	2573	2386	2510	2613	2738
Handover	1825	1945	2045	1965	2025	2125	2160	2280	2390	2345	2470	2580	2390	2510	2635	2735
Prepare	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	yes	yes
Time of	1830	1960	-	1968	2026	-	2161	2290	2391	2354	-	-	2388	2512	2615	2739
Handover	1825	1945	-	1965	2025	-	2160	2280	2390	2350	-	-	2395	2510	2660	2735
Accept	yes	yes	-	yes	yes	-	yes	yes	yes	yes	-	-	yes	yes	no	yes
Time of	1957	1975	-	2022	2041	-	2306	2310	2412	2492	-	-	2529	2531	2634	2759
Handback	1950	1965	-	2030	2045	-	2290	2310	2410	2475	-	-	2525	2535	2665	2760
	yes	yes	-	yes	yes	-	yes	yes	yes	no	-	-	yes	yes	yes	yes

[1]SAINT Sample Mean from 25 Replications
[2]Real-time value
[3]Accept Hypothesis of Histogram Test?

HISTOGRAM FOR

TIME OF HANDBACK FOR RPV 10

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2300 - 2305	0	0.000
2310 - 2315	0	0.000
2320 - 2325	0	0.000
2330 - 2335	0	0.000
2340 - 2345	0	0.000
2350 - 2355	0	0.000
2360 - 2365	0	0.000
2370 - 2375	0	0.000
2380 - 2385	0	0.000
2390 - 2395	0	0.000
2400 - 2405	0	0.000
2410 - 2415	0	0.000
2420 - 2425	0	0.000
2430 - 2435	0	0.000
2440 - 2445	0	0.000
2450 - 2455	0	0.000
2460 - 2465	0	0.000
2470 - 2475	0	0.000
2480 - 2485	11	.440
2490 - 2495	7	.280
2500 - 2505	7	.280
2510 - 2515	0	0.000
2520 - 2525	0	0.000
2530 - 2535	0	0.000
2540 - 2545	0	0.000
2550 - 2555	0	0.000
2560 - 2565	0	0.000
2570 - 2575	0	0.000
2580 - 2585	0	0.000
2590 - 2595	0	0.000

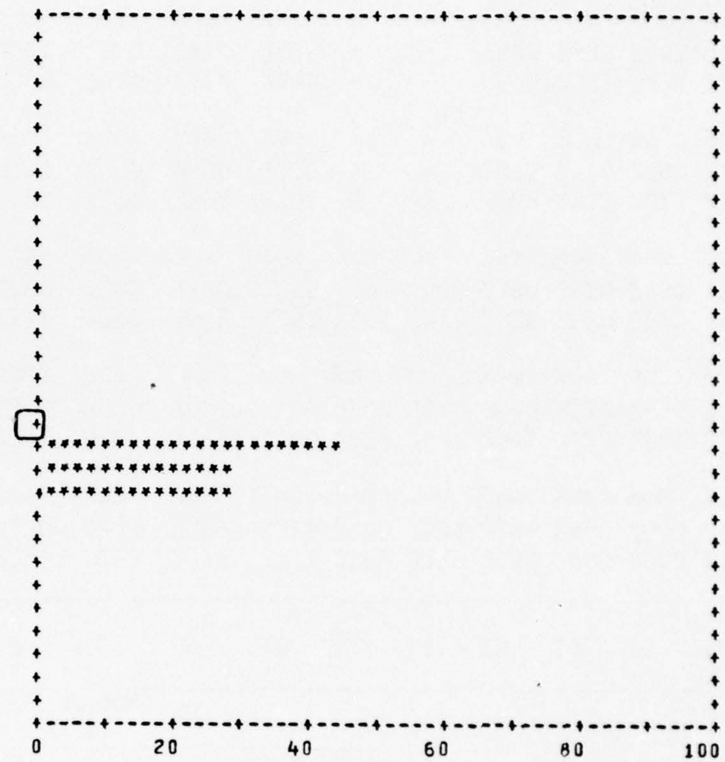


Figure 27. Histogram for Time of Handback for RPV 10.

HISTOGRAM FOR

TIME OF POP-DOWN MANEUVER FOR RPV 10

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2300 - 2305	0	0.000
2310 - 2315	0	0.000
2320 - 2325	0	0.000
2330 - 2335	0	0.000
2340 - 2345	0	0.000
2350 - 2355	0	0.000
2360 - 2365	0	0.000
2370 - 2375	0	0.000
2380 - 2385	0	0.000
2390 - 2395	0	0.000
2400 - 2405	0	0.000
2410 - 2415	0	0.000
2420 - 2425	0	0.000
2430 - 2435	0	0.000
2440 - 2445	0	0.000
2450 - 2455	0	0.000
2460 - 2465	0	0.000
2470 - 2475	0	0.000
2480 - 2485	0	0.000
2490 - 2495	3	.120
2500 - 2505	13	.520
2510 - 2515	9	.360
2520 - 2525	0	0.000
2530 - 2535	0	0.000
2540 - 2545	0	0.000
2550 - 2555	0	0.000
2560 - 2565	0	0.000
2570 - 2575	0	0.000
2580 - 2585	0	0.000
2590 - 2595	0	0.000

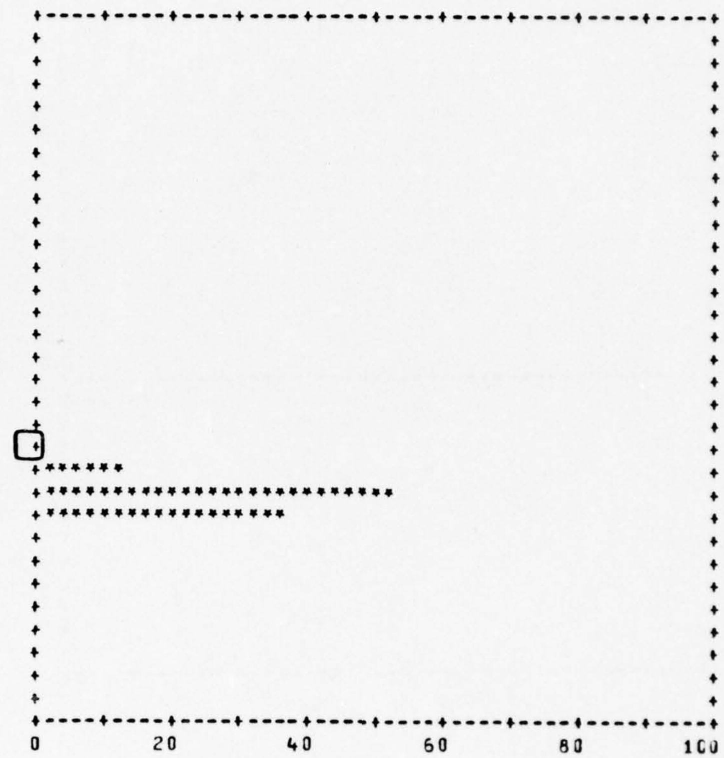


Figure 28. Histogram for Time of Pop-down for RPV 10.

HISTOGRAM FOR

TIME OF HANDOVER PREPARE FOR RPV 12

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2450 - 2455	0	0.000
2460 - 2465	0	0.000
2470 - 2475	0	0.000
2480 - 2485	0	0.000
2490 - 2495	0	0.000
2500 - 2505	0	0.000
2510 - 2515	0	0.000
2520 - 2525	0	0.000
2530 - 2535	0	0.000
2540 - 2545	0	0.000
2550 - 2555	0	0.000
2560 - 2565	3	.120
2570 - 2575	22	.880
2580 - 2585	0	0.000
2590 - 2595	0	0.000
2600 - 2605	0	0.000
2610 - 2615	0	0.000
2620 - 2625	0	0.000
2630 - 2635	0	0.000
2640 - 2645	0	0.000
2650 - 2655	0	0.000
2660 - 2665	0	0.000
2670 - 2675	0	0.000
2680 - 2685	0	0.000
2690 - 2695	0	0.000
2700 - 2705	0	0.000
2710 - 2715	0	0.000
2720 - 2725	0	0.000
2730 - 2735	0	0.000
2740 - 2745	0	0.000

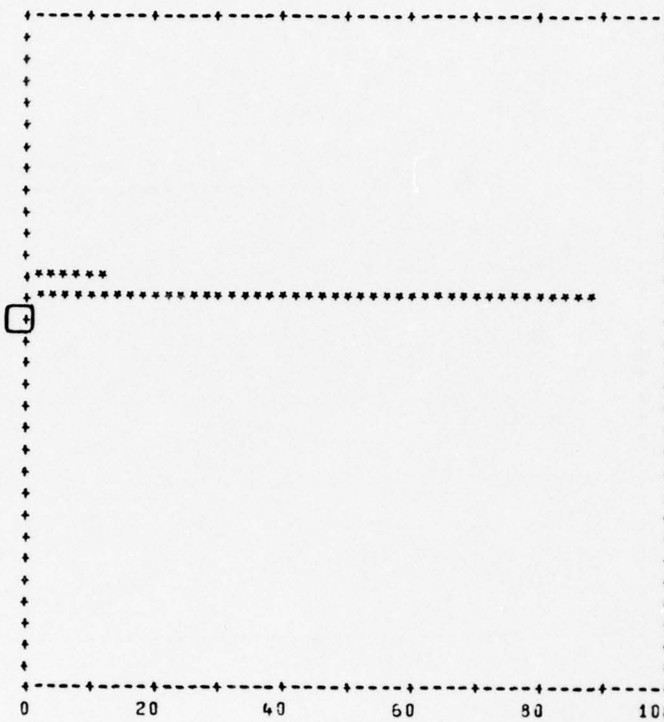


Figure 29. Histogram for Time of Handover-Prepare for RPV 12.

HISTOGRAM FOR

TIME OF POP-DOWN MANEUVER FOR RPV 12

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2450 - 2455	0	0.000
2460 - 2465	0	0.000
2470 - 2475	0	0.000
2480 - 2485	0	0.000
2490 - 2495	0	0.000
2500 - 2505	0	0.000
2510 - 2515	0	0.000
2520 - 2525	0	0.000
2530 - 2535	0	0.000
2540 - 2545	0	0.000
2550 - 2555	0	0.000
2560 - 2565	0	0.000
2570 - 2575	0	0.000
2580 - 2585	0	0.000
2590 - 2595	5	.200
2600 - 2605	13	.520
2610 - 2615	4	.160
2620 - 2625	3	.120
2630 - 2635	0	0.000
2640 - 2645	0	0.000
2650 - 2655	0	0.000
2660 - 2665	0	0.000
2670 - 2675	0	0.000
2680 - 2685	0	0.000
2690 - 2695	0	0.000
2700 - 2705	0	0.000
2710 - 2715	0	0.000
2720 - 2725	0	0.000
2730 - 2735	0	0.000
2740 - 2745	0	0.000

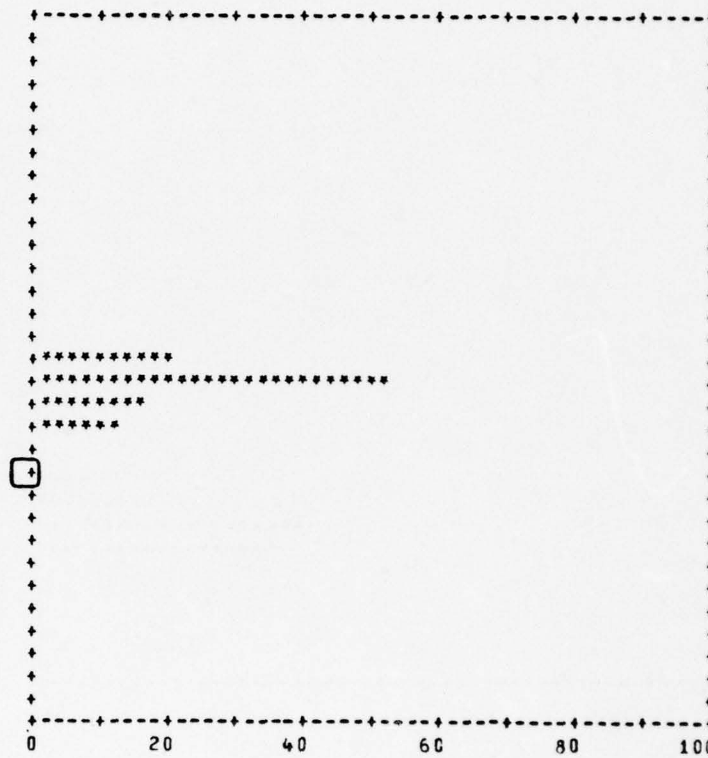


Figure 30. Histogram for Time of Pop-down for RPV 12.

HISTOGRAM FOR

TIME OF HANDOVER ACCEPT FOR RPV 15

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2550 - 2555	0	0.000
2560 - 2565	0	0.000
2570 - 2575	0	0.000
2580 - 2585	0	0.000
2590 - 2595	0	0.000
2600 - 2605	8	.320
2610 - 2615	10	.400
2620 - 2625	4	.160
2630 - 2635	1	.040
2640 - 2645	1	.040
2650 - 2655	1	.040
2660 - 2665	0	0.000
2670 - 2675	0	0.000
2680 - 2685	0	0.000
2690 - 2695	0	0.000
2700 - 2705	0	0.000
2710 - 2715	0	0.000
2720 - 2725	0	0.000
2730 - 2735	0	0.000
2740 - 2745	0	0.000
2750 - 2755	0	0.000
2760 - 2765	0	0.000
2770 - 2775	0	0.000
2780 - 2785	0	0.000
2790 - 2795	0	0.000
2800 - 2805	0	0.000
2810 - 2815	0	0.000
2820 - 2825	0	0.000
2830 - 2835	0	0.000
2840 - 2845	0	0.000

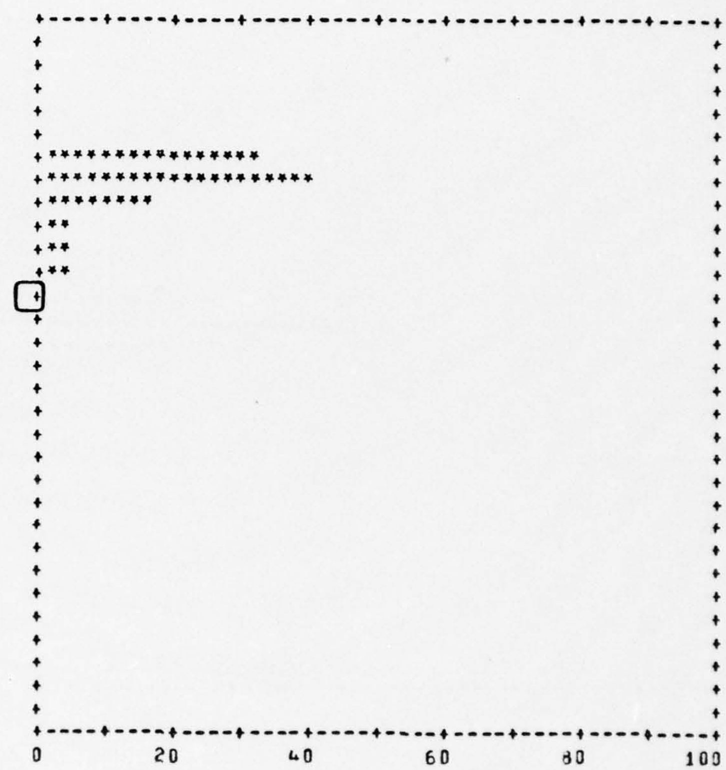


Figure 31. Histogram for Time of Handover Accept for RPV 15.

HISTOGRAM FOR

TIME OF POP-DOWN MANEUVER FOR RPV 15

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2550 - 2555	0	0.000
2560 - 2565	0	0.000
2570 - 2575	0	0.000
2580 - 2585	0	0.000
2590 - 2595	0	0.000
2600 - 2605	0	0.000
2610 - 2615	0	0.000
2620 - 2625	1	.040
2630 - 2635	13	.520
2640 - 2645	4	.160
2650 - 2655	5	.200
2660 - 2665	2	.080
2670 - 2675	0	0.000
2680 - 2685	0	0.000
2690 - 2695	0	0.000
2700 - 2705	0	0.000
2710 - 2715	0	0.000
2720 - 2725	0	0.000
2730 - 2735	0	0.000
2740 - 2745	0	0.000
2750 - 2755	0	0.000
2760 - 2765	0	0.000
2770 - 2775	0	0.000
2780 - 2785	0	0.000
2790 - 2795	0	0.000
2800 - 2805	0	0.000
2810 - 2815	0	0.000
2820 - 2825	0	0.000
2830 - 2835	0	0.000
2840 - 2845	0	0.000

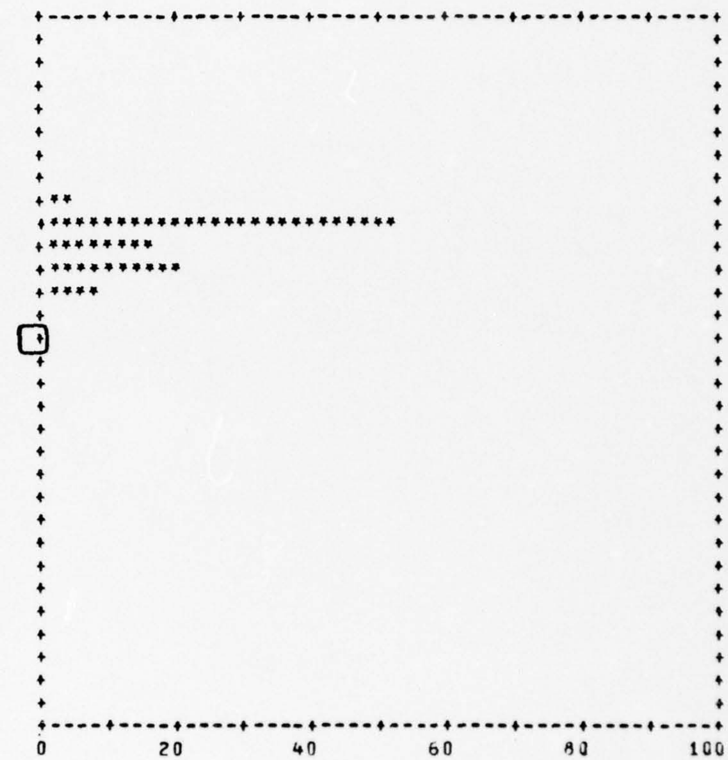


Figure 32. Histogram for Time of Pop-down for RPV 15.

exceptions. The inconsistencies of operator actions will need to be addressed when an attempt is made to further develop the SAINT model.

SECTION V

CONCLUSIONS

The results of the evaluation of the SAINT model of the RPV/DCF simulation show that the SAINT model is a satisfactory representation of the one team-one mission real-time simulation for 265 of the 281 measures of system performance analyzed, or 94%. These results are sufficiently conclusive in satisfying the objectives of this effort. In addition, the SAINT simulation model proved to be more efficient, in terms of computer processing time, than the real-time simulation. The SAINT simulation of the one team-one mission scenario required approximately five minutes of computer processing time, while the real-time simulation of the same scenario required approximately ninety minutes.

In addition to providing a satisfactory representation of the real-time simulation, the SAINT model proved to be invaluable in locating inaccuracies in the real-time simulation program. This fact indicates the usefulness of a SAINT model as an independent back-up simulation of a real-time effort. Using SAINT as in this effort, a dual model of a real-time simulation can be constructed and exercised. The outputs of the two systems can be compared. This analysis will indicate inaccuracies in the real-time simulation as well as inaccuracies in the SAINT model. This dual simulation approach offers substantial savings in time and output loss due to inaccuracies in the real-time simulation and a substantial increase in the confidence of the results of both simulations.

For the majority of statistics analyzed, the results indicate that the operator performance moderator functions developed and employed in the SAINT model are satisfactory. However, the results do point to a need for additional moderator function development, and indicate that such development will provide improved results.

The SAINT model of the RPV/DCF real-time simulation has been successfully developed. It has been satisfactorily evaluated with respect to one mission of the real-time simulation. The applicability of the SAINT modeling technique to the analysis of the RPV/DCF system has been demonstrated.

Since the real-time simulation includes complex man-machine interactions, the usefulness and power of the SAINT technique in representing those interactions have been demonstrably shown. A complex man-machine system can be

modeled and simulated using SAINT. Thus, the system can be studied in a controlled environment without disruption to its operation and at a relatively low cost. Certainly, expertise in the area of human performance is required to provide generally applicable moderator functions that predict operator efficiency and operator decisions based on system characteristics. However, SAINT provides the framework through which this expertise can be effectively channeled, and through which system performance measures can be obtained based on subsystem descriptions.

SECTION VI

RECOMMENDATIONS

The SAINT model of the RPV/DCF simulation has been shown to be a satisfactory representation of the one team, one mission scenario that was analyzed. While this is a very significant result, the model should be evaluated for additional missions and operator groups. When this is completed, the SAINT model, in conjunction with the RPV/DCF real-time simulation, will be an extremely useful predictive and analytical tool for the evaluation of RPV/DCF system design and for the analysis of operator performance in relation to varying system parameters. This section outlines the procedure necessary to obtain such a model.

The real-time RPV/DCF mission analyzed in this effort, as shown in Section IV, includes 16 RPVs and is performed by operator group 1. The next stage of the development effort should be to obtain a SAINT model that satisfactorily represents all 16 RPV missions performed by operator group 1. In order to achieve such a model, it is anticipated that the human performance moderator functions included in the original model will need further development and refinement in the following areas:

1. Preferential treatment of one type of RPV over another by an operator

2. Preferential treatment of individual RPVs over others by an operator

3. Determination of a new velocity for an RPV for purposes of ETA manipulation by an operator

4. The time of acceptance and release of control of an RPV by the terminal pilot

5. The time of handover and handback operations for an RPV by an operator

6. Unsuccessful or unattempted performance of a required task by an operator

In addition to the refinement of moderator functions, some alterations to the structure and parameters of the model may be necessary. It should be noted that the evaluation procedure employed at this point will be more rigorous than that of Section IV due to the increase in the number of available observations of the real-time simulation.

Once a representative model for all 16 RPV missions performed by operator group 1 has been developed, the model should be evaluated for missions performed by the same operator group that include an increased number of RPVs. Once again, the human performance moderator functions developed in the previous step may require additional refinement. In addition, this stage of the development process will provide a check on the task performance times specified in the original model. In that model, it was assumed that task performance times were dominated by frame update times. If the assumption proves to be invalid when applied to missions consisting of more than 16 RPVs, appropriate adjustments need to be made to the task performance times and/or associated moderator functions.

Once the model has been satisfactorily evaluated for all missions performed by operator group 1, the analysis shifts to other operator groups. For each group of operators selected, the procedure will be similar to that used for operator group 1. The objective is to achieve a representative model for all operator groups and all missions.

When the SAINT model of the RPV/DCF simulation is satisfactorily evaluated for all operator groups and all missions, it will be an extremely useful and low cost tool that can be used in conjunction with the real-time simulation to analyze RPV/DCF design. It can be used for feasibility studies and value analyses of system design alternatives prior to their implementation in the real-time system, as well as providing an additional verification of the operation of the real-time simulation program.

APPENDIX I

HISTOGRAMS FOR OPERATOR COMMAND STATISTICS

This appendix presents the histograms for selected operator command statistics used for the validation analysis presented in Section IV. The histograms that appear in this appendix are listed below in the order in which they appear:

1) Number of patches during enroute for each of the 16 RPVs

2) Number of patches during return for each of the 16 RPVs

3) Number of velocity changes during enroute for each of the 16 RPVs

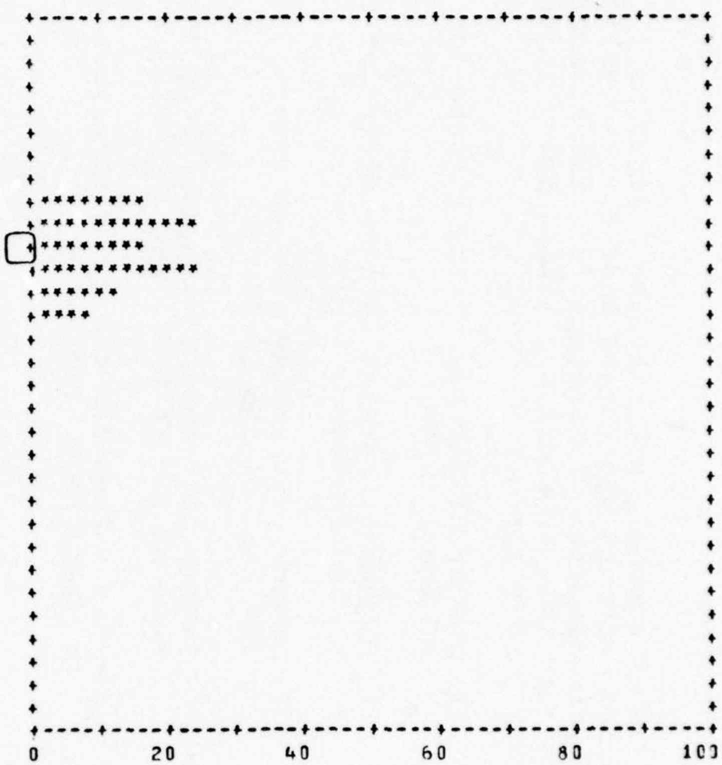
4) Number of velocity changes during return for each of the 16 RPVs

The real-time values for these variables are indicated by a "$\square$" on these histograms.

HISTOGRAM FOR

NUMBER OF PATCHES, ENROUTE FOR RPV 1

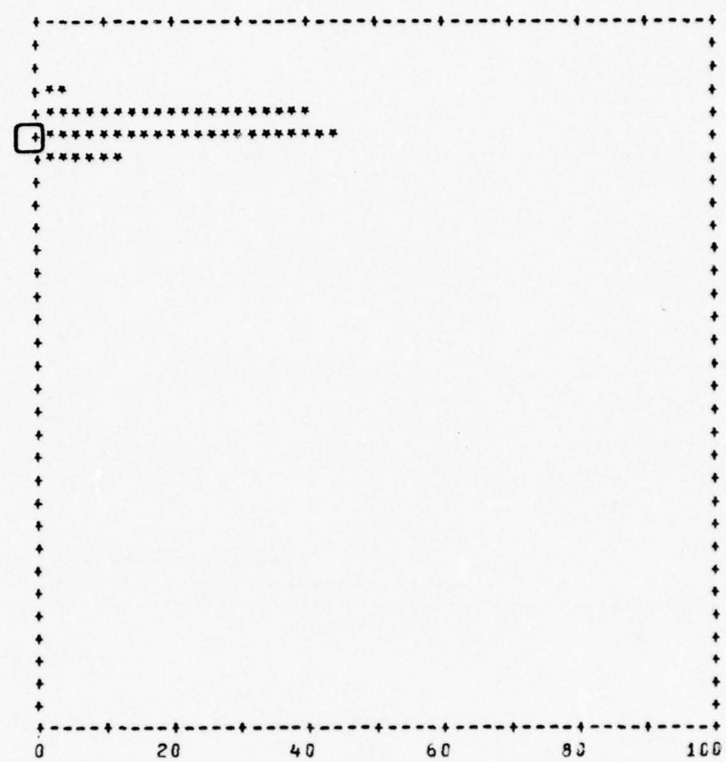
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	0	0.000
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	4	.160
16 - 17	6	.240
18 - 19	4	.160
20 - 21	6	.240
22 - 23	3	.120
24 - 25	2	.080
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, ENROUTE FOR RPV 2

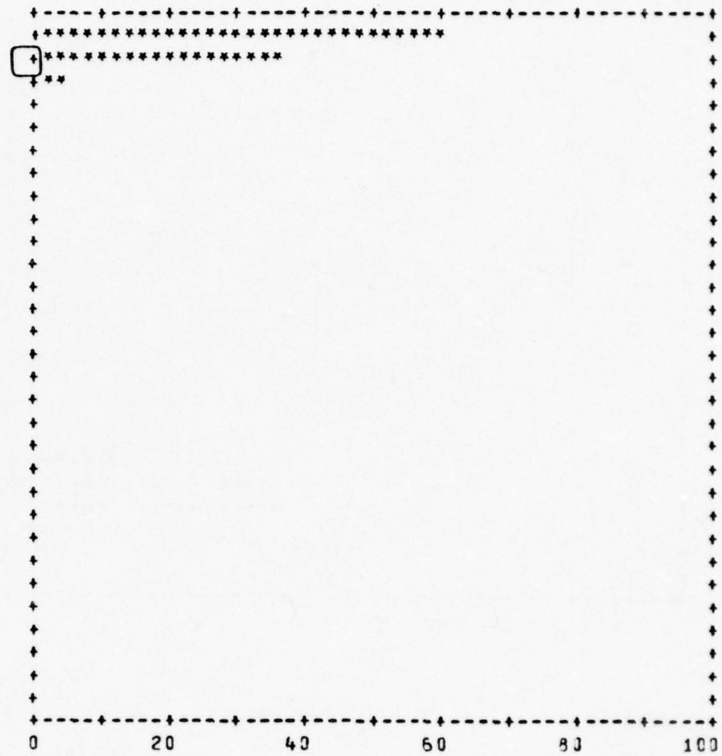
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	1	.040
6 - 7	10	.400
8 - 9	11	.440
10 - 11	3	.120
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	0	0.000
22 - 23	0	0.000
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF MATCHES, ENROUTE FOR RPV 3

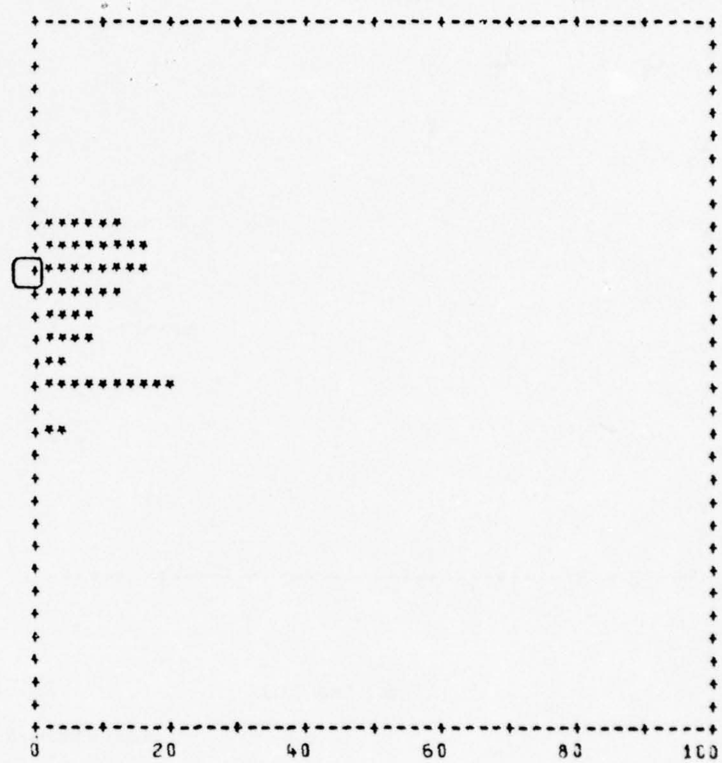
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	15	.600
2 - 3	9	.360
4 - 5	1	.040
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	0	0.000
22 - 23	0	0.000
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, ENROUTE FOR PPV 4

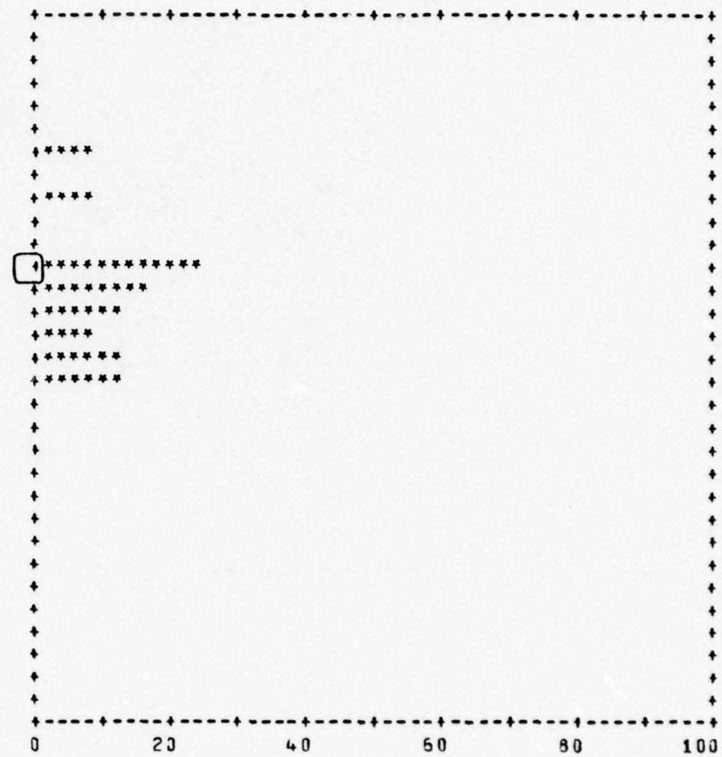
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	0	0.000
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	3	.120
18 - 19	4	.160
20 - 21	4	.160
22 - 23	3	.120
24 - 25	2	.080
26 - 27	2	.080
28 - 29	1	.040
30 - 31	5	.200
32 - 33	0	0.000
34 - 35	1	.040
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, ENROUTE FOR RPV 5

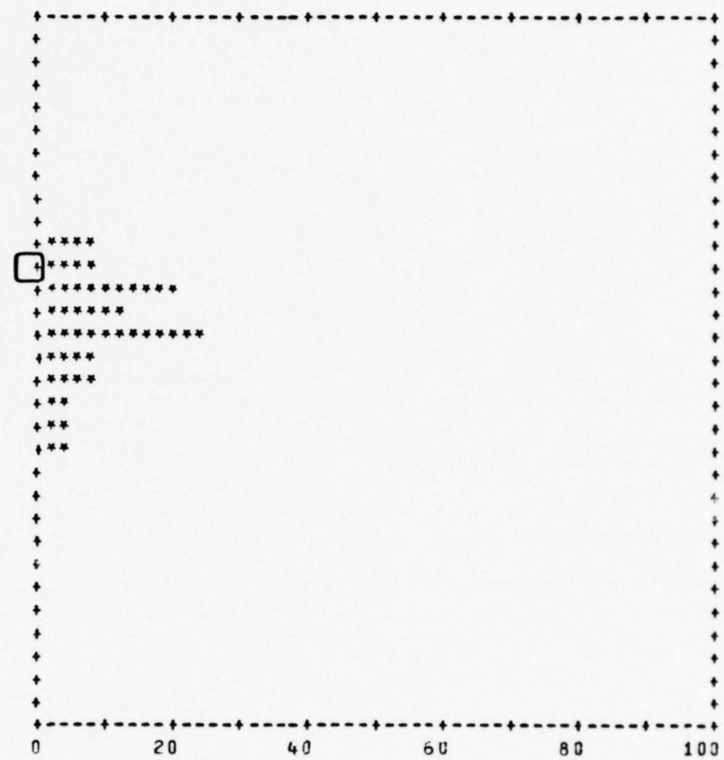
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	0	0.000
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	2	.080
12 - 13	0	0.000
14 - 15	2	.080
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	6	.240
22 - 23	4	.160
24 - 25	3	.120
26 - 27	2	.080
28 - 29	3	.120
30 - 31	3	.120
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, ENROUTE   FOR RPV 6

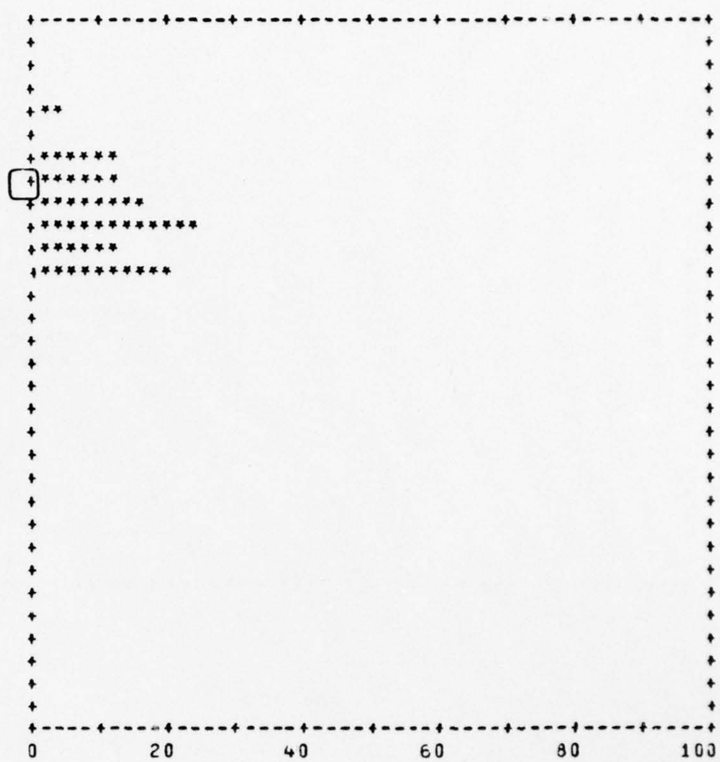
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	0	0.000
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	2	.080
20 - 21	2	.080
22 - 23	5	.200
24 - 25	3	.120
26 - 27	6	.240
28 - 29	2	.080
30 - 31	2	.080
32 - 33	1	.040
34 - 35	1	.040
36 - 37	1	.040
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, ENROUTE FOR RPV 7

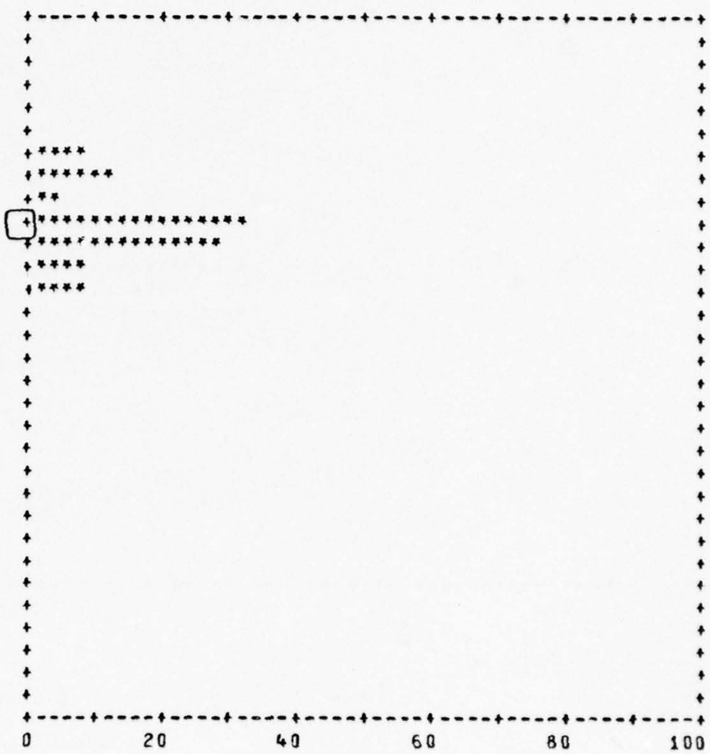
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	0	0.000
6 - 7	1	.040
8 - 9	0	0.000
10 - 11	3	.120
12 - 13	3	.120
14 - 15	4	.160
16 - 17	6	.240
18 - 19	3	.120
20 - 21	5	.200
22 - 23	0	0.000
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, ENROUTE FOR RPV 8

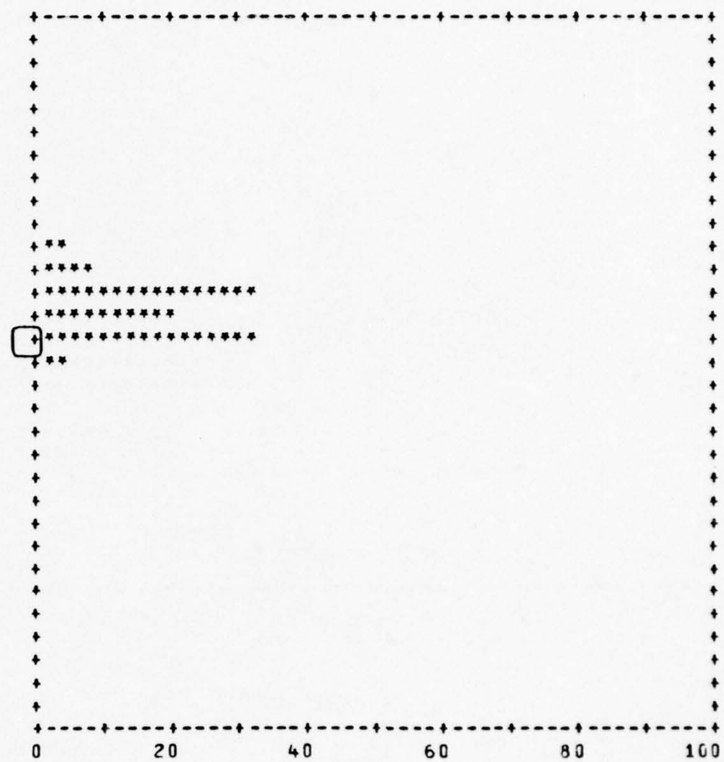
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	0	0.000
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	2	.080
12 - 13	3	.120
14 - 15	1	.040
16 - 17	8	.320
18 - 19	7	.280
20 - 21	2	.080
22 - 23	2	.080
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, ENROUTE FOR RPV 9

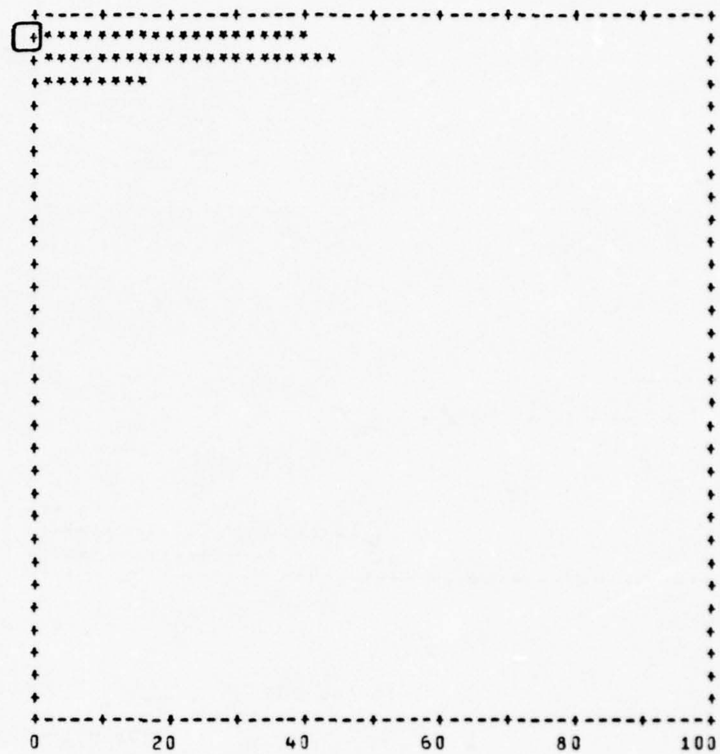
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	0	0.000
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	1	.040
20 - 21	2	.030
22 - 23	8	.320
24 - 25	5	.200
26 - 27	8	.320
28 - 29	1	.040
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FCR

NUMBEF OF FATCHES, ENROLTE FOR RPV 10

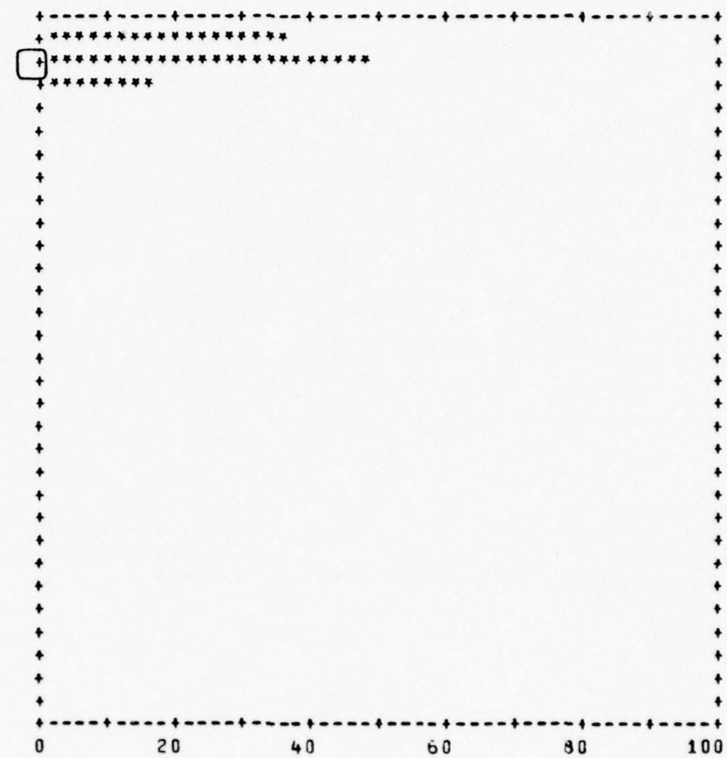
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	10	.400
2 - 3	11	.440
4 - 5	4	.150
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	0	0.000
22 - 23	0	0.000
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, ENROUTE FOR RPV 11

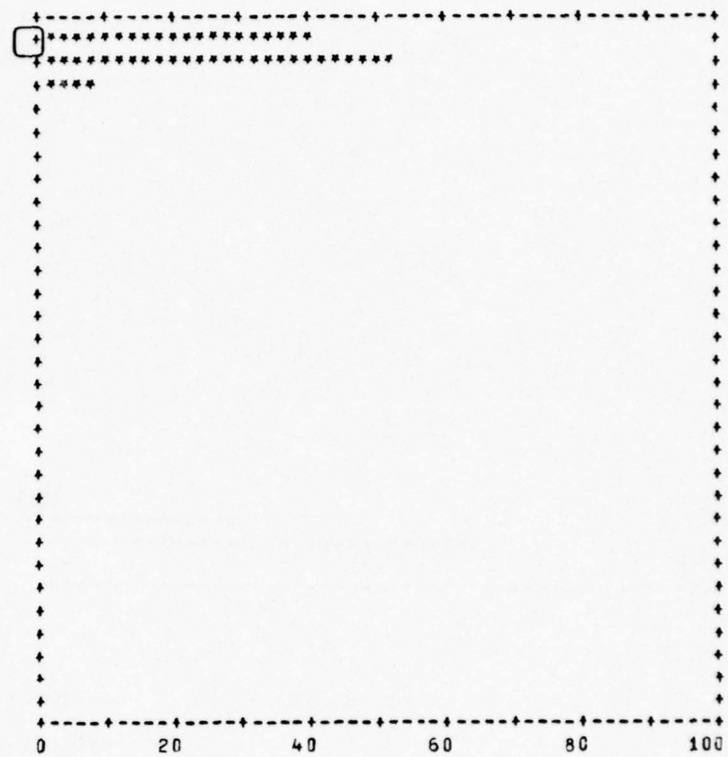
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	9	.360
2 - 3	12	.480
4 - 5	4	.160
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	0	0.000
22 - 23	0	0.000
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, ENROUTE FOR RPV 12

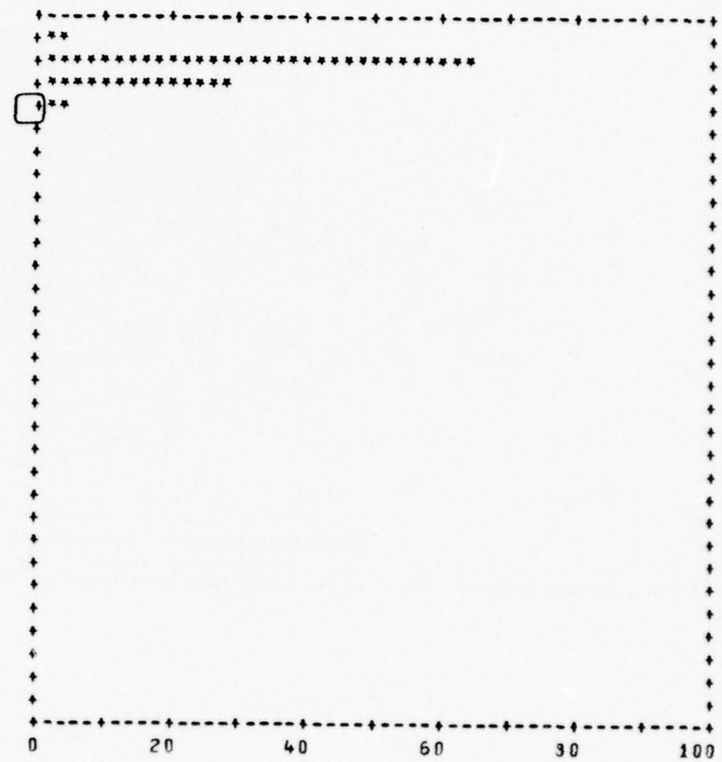
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	10	.400
2 - 3	13	.520
4 - 5	2	.080
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	0	0.000
22 - 23	0	0.000
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, ENROUTE FOR RPV 13

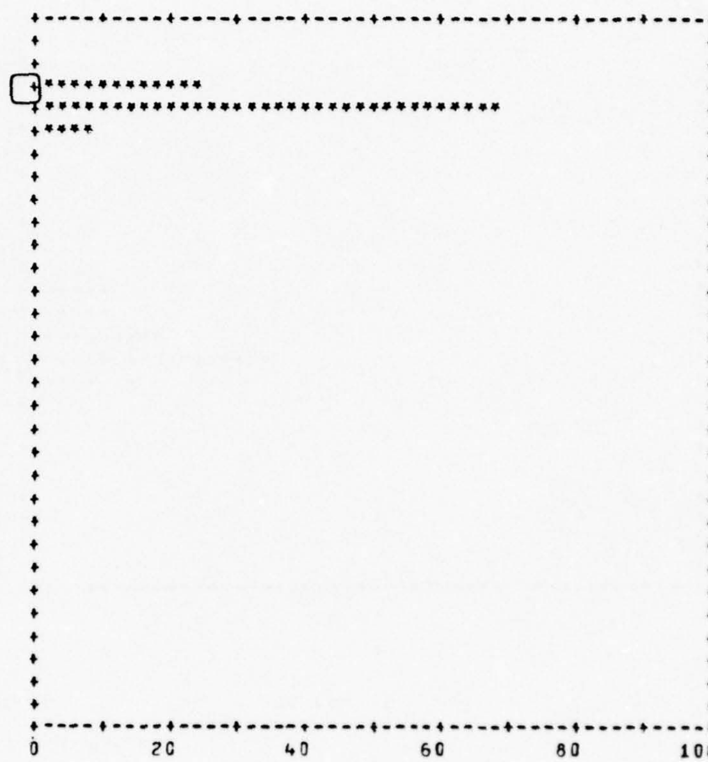
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	1	.040
2 - 3	16	.640
4 - 5	7	.280
6 - 7	1	.040
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	0	0.000
22 - 23	0	0.000
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, ENROUTE FOR RPV 14

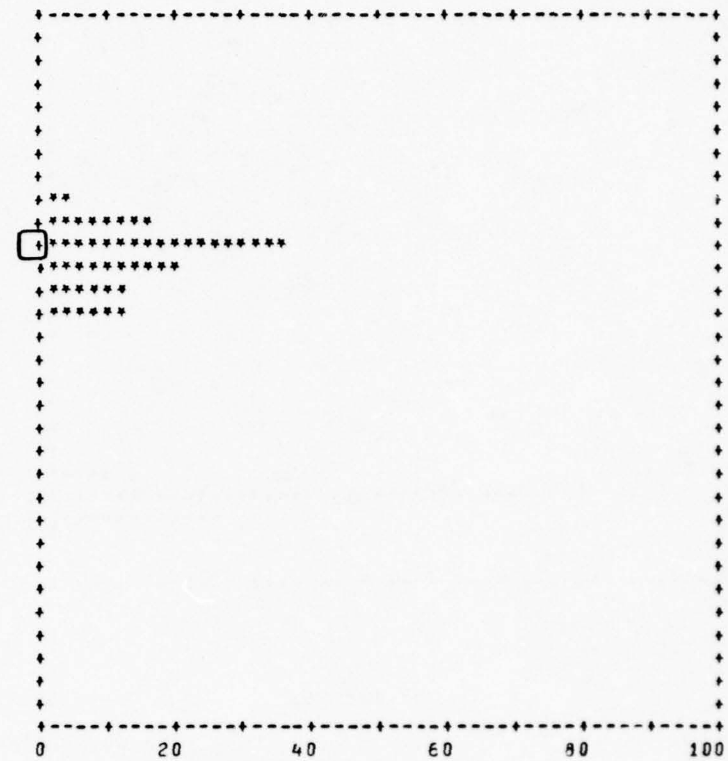
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	6	.240
6 - 7	17	.680
8 - 9	2	.080
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	0	0.000
22 - 23	0	0.000
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, ENROUTE FOR RPV 15

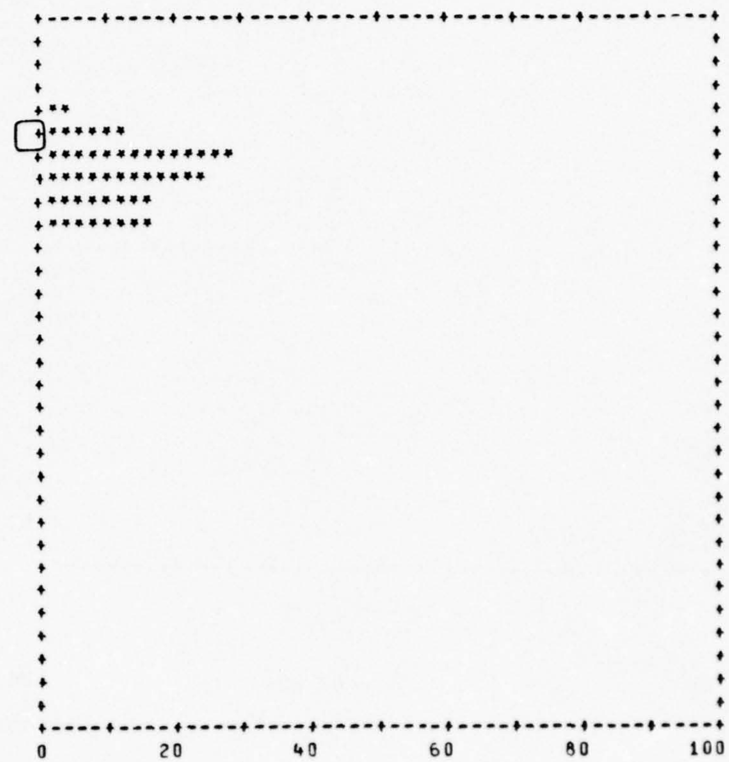
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	0	0.000
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	1	.040
16 - 17	4	.160
18 - 19	9	.360
20 - 21	5	.200
22 - 23	3	.120
24 - 25	3	.120
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, ENROUTE FOR RPV 16

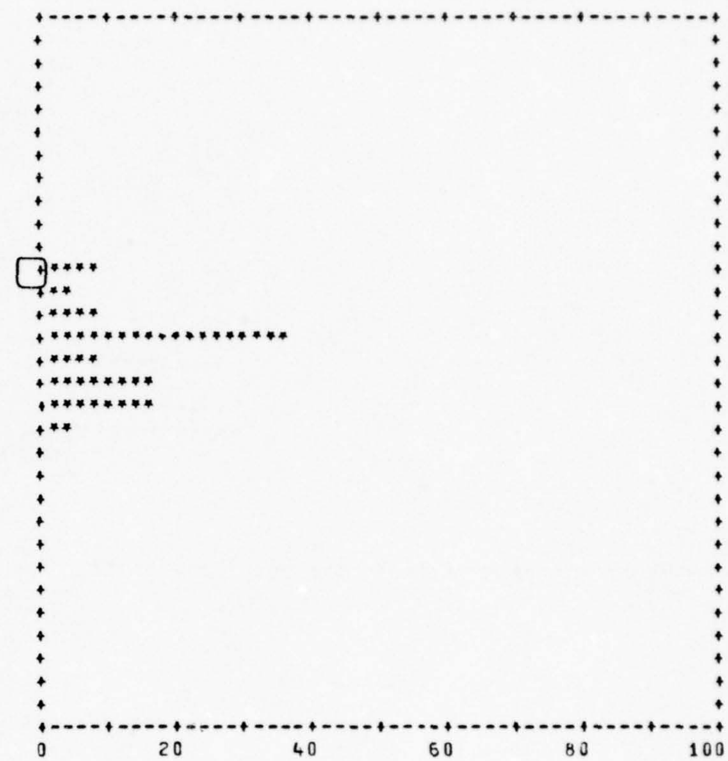
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	0	0.000
6 - 7	1	.040
8 - 9	3	.120
10 - 11	7	.280
12 - 13	6	.240
14 - 15	4	.160
16 - 17	4	.160
18 - 19	0	0.000
20 - 21	0	0.000
22 - 23	0	0.000
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, RETURN FOR RPV 1

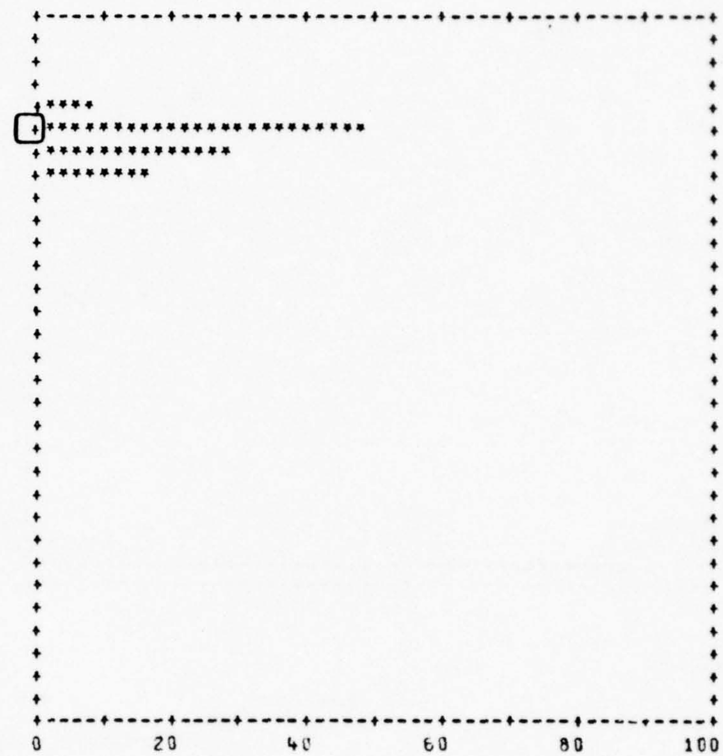
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	0	0.000
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	2	.080
22 - 23	1	.040
24 - 25	2	.080
26 - 27	9	.360
28 - 29	2	.080
30 - 31	4	.160
32 - 33	4	.160
34 - 35	1	.040
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, RETURN FOR RPV 2

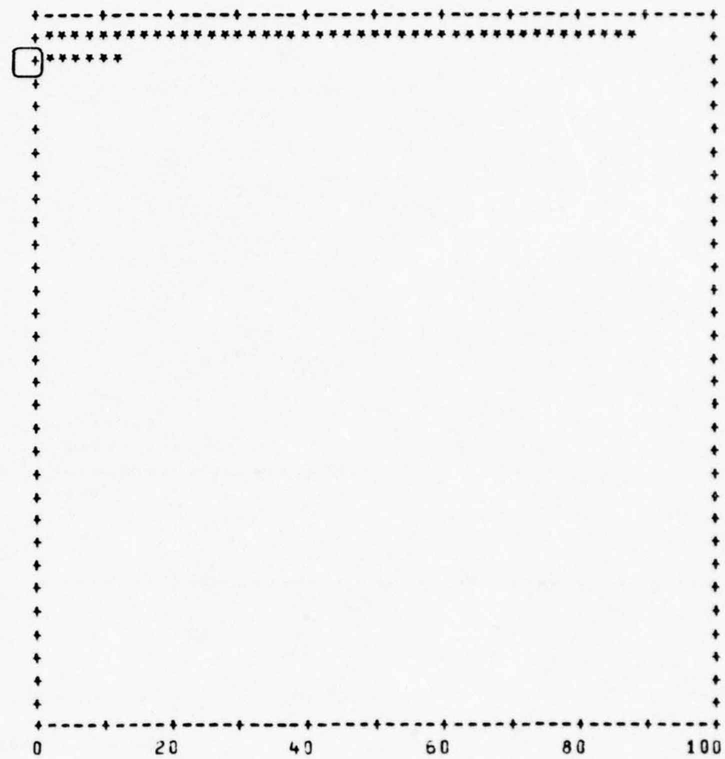
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	0	0.000
6 - 7	2	.080
8 - 9	12	.480
10 - 11	7	.280
12 - 13	4	.160
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	0	0.000
22 - 23	0	0.000
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, RETURN FOR RPV 3

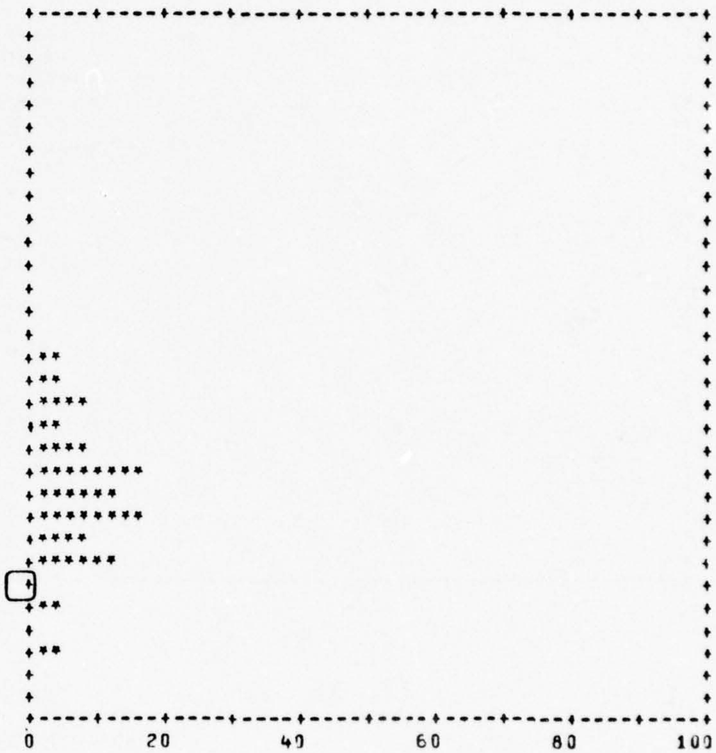
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	22	.880
2 - 3	3	.120
4 - 5	0	0.000
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	0	0.000
22 - 23	0	0.000
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, RETURN FOR PPV 4

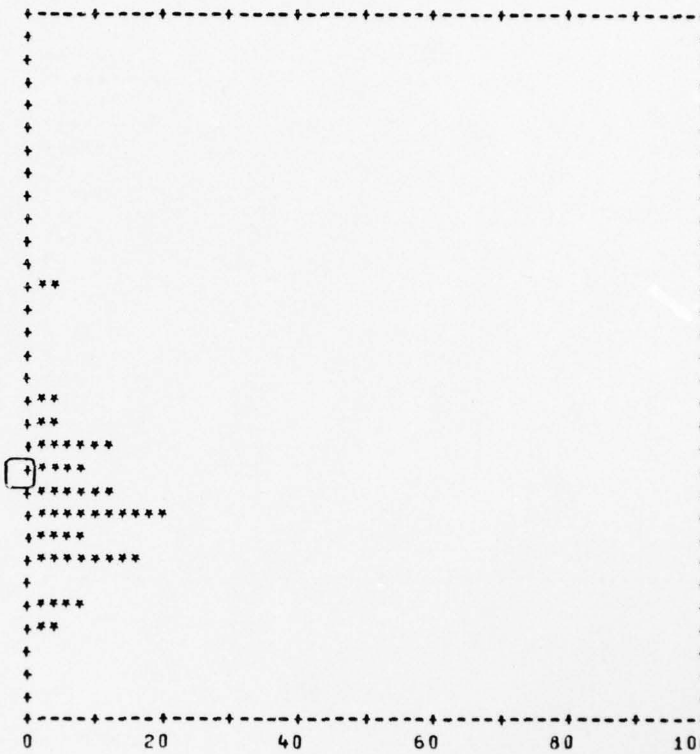
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	0	0.000
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	0	0.000
22 - 23	0	0.000
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	1	.040
30 - 31	1	.040
32 - 33	2	.030
34 - 35	1	.040
36 - 37	2	.080
38 - 39	4	.160
40 - 41	3	.120
42 - 43	4	.160
44 - 45	2	.030
46 - 47	3	.120
48 - 49	0	0.000
50 - 51	1	.040
52 - 53	0	0.000
54 - 55	1	.040
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, RETURN FOR RPV 5

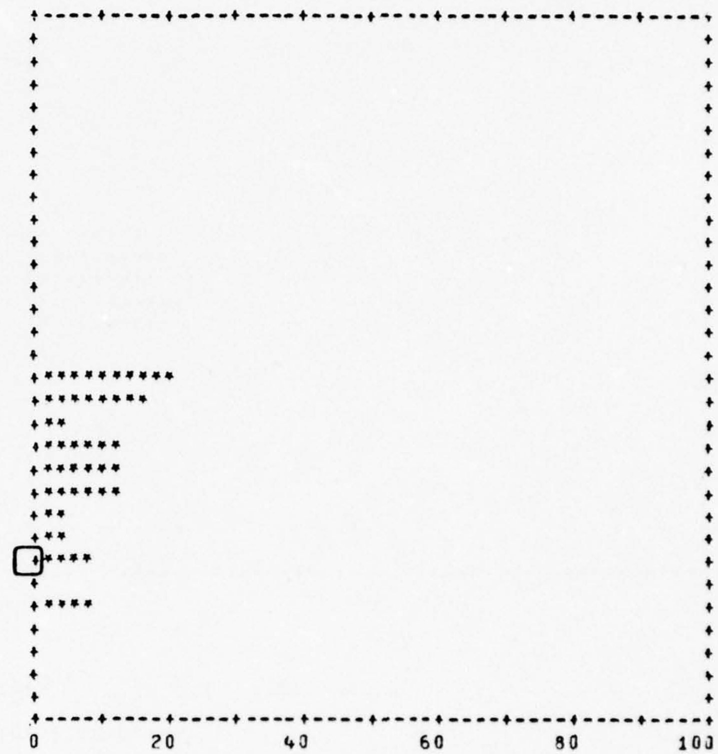
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	0	0.000
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	0	0.000
22 - 23	1	.040
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	1	.040
34 - 35	1	.040
36 - 37	3	.120
38 - 39	2	.080
40 - 41	3	.120
42 - 43	5	.200
44 - 45	2	.080
46 - 47	4	.160
48 - 49	0	0.000
50 - 51	2	.080
52 - 53	1	.040
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, RETURN FOR RPV 6

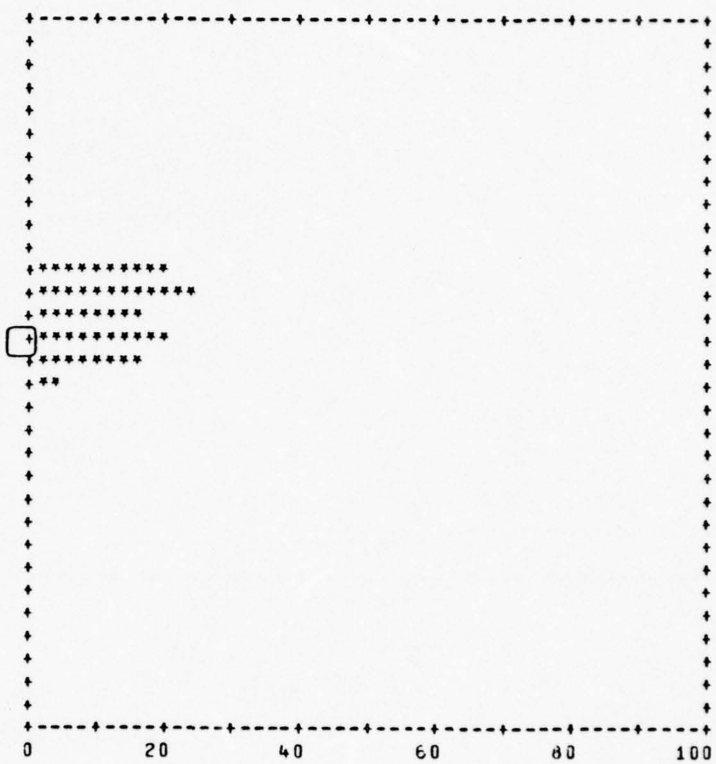
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	0	0.000
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	0	0.000
22 - 23	0	0.000
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	5	.200
32 - 33	4	.160
34 - 35	1	.040
36 - 37	3	.120
38 - 39	3	.120
40 - 41	3	.120
42 - 43	1	.040
44 - 45	1	.040
46 - 47	2	.080
48 - 49	0	0.000
50 - 51	2	.080
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, RETURN FOR RPV 7

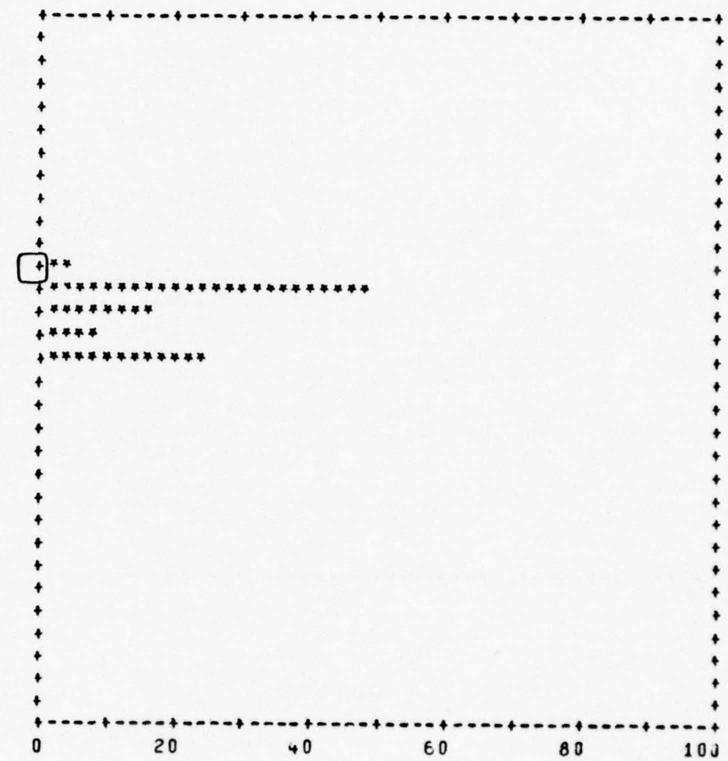
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	0	0.000
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	5	.200
22 - 23	6	.240
24 - 25	4	.160
26 - 27	5	.200
28 - 29	4	.160
30 - 31	1	.040
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, RETURN FOR RPV 8

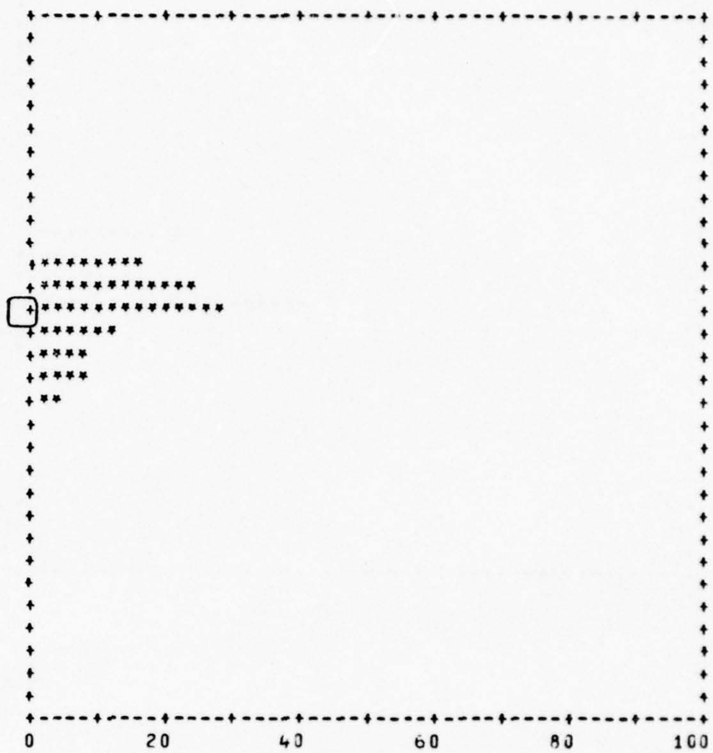
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	0	0.000
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	1	.040
22 - 23	12	.480
24 - 25	4	.160
26 - 27	2	.080
28 - 29	6	.240
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF BATCHES, RETURN FOR RPV 9

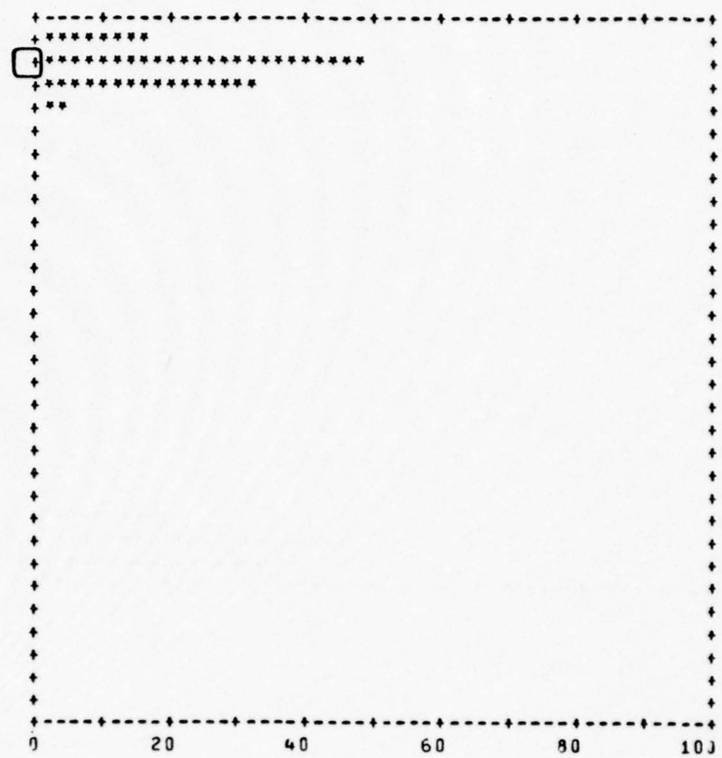
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	0	0.000
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	4	.160
22 - 23	6	.240
24 - 25	7	.280
26 - 27	3	.120
28 - 29	2	.080
30 - 31	2	.080
32 - 33	1	.040
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, RETURN FOR RPV 10

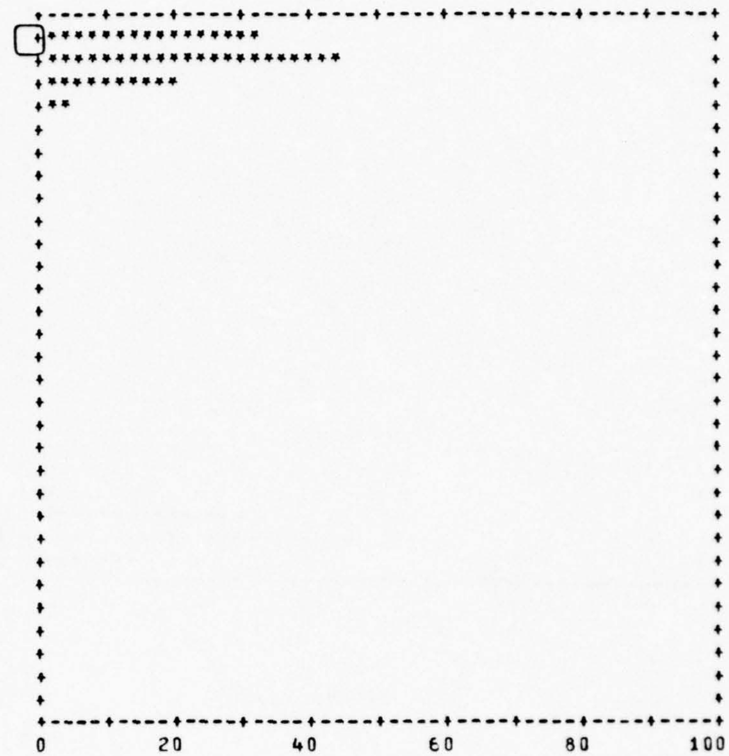
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	4	.160
2 - 3	12	.480
4 - 5	8	.320
6 - 7	1	.040
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	0	0.000
22 - 23	0	0.000
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, RETURN FOR RPV 11

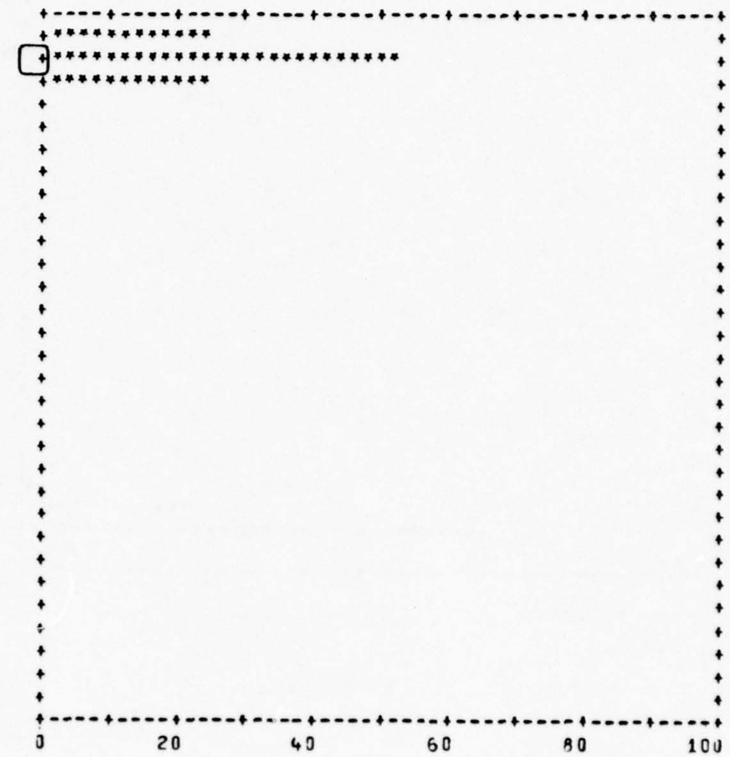
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	8	.320
2 - 3	11	.440
4 - 5	5	.200
6 - 7	1	.040
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	0	0.000
22 - 23	0	0.000
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, RETURN FOR RPV 12

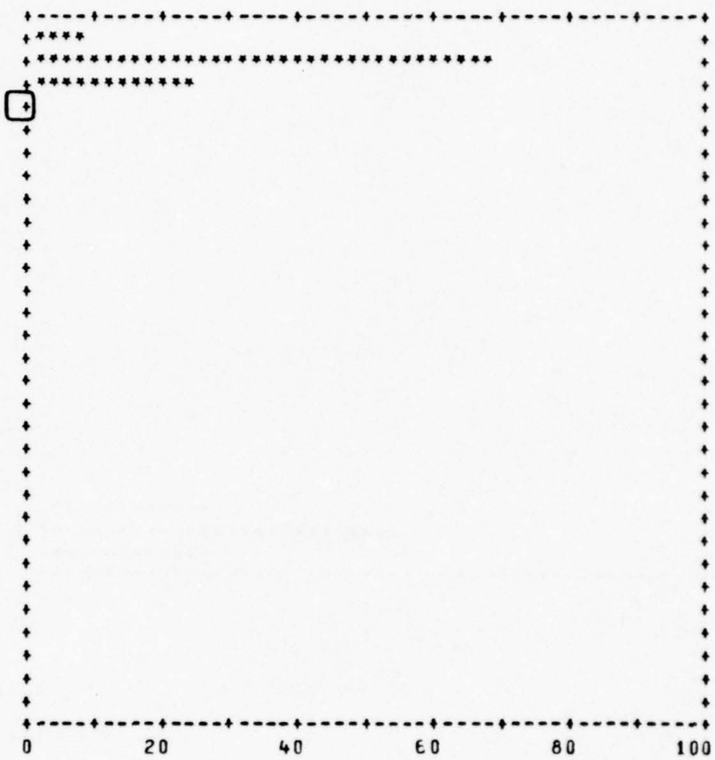
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	6	.240
2 - 3	13	.520
4 - 5	6	.240
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	0	0.000
22 - 23	0	0.000
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, RETURN FOR RPV 13

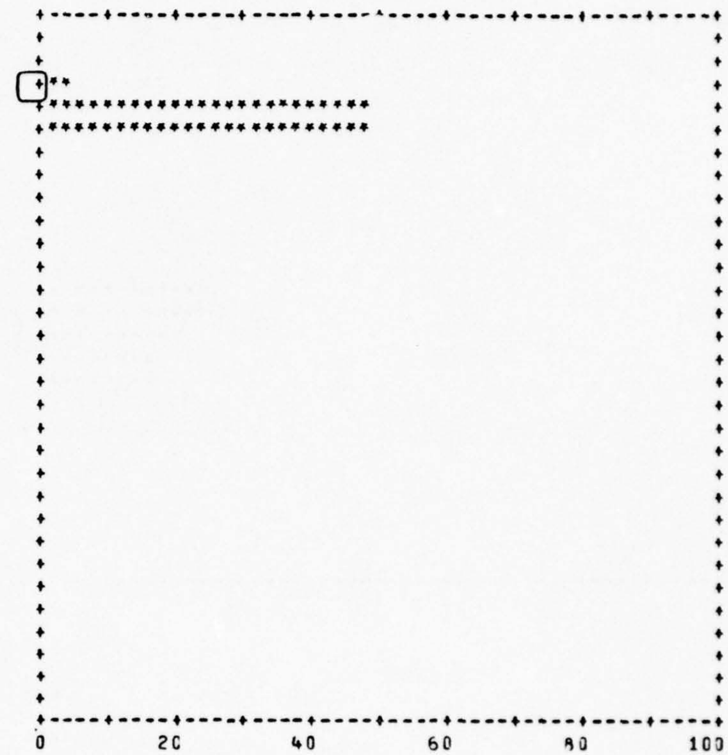
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	2	.080
2 - 3	17	.680
4 - 5	6	.240
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	0	0.000
22 - 23	0	0.000
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, RETURN FOR RPV 14

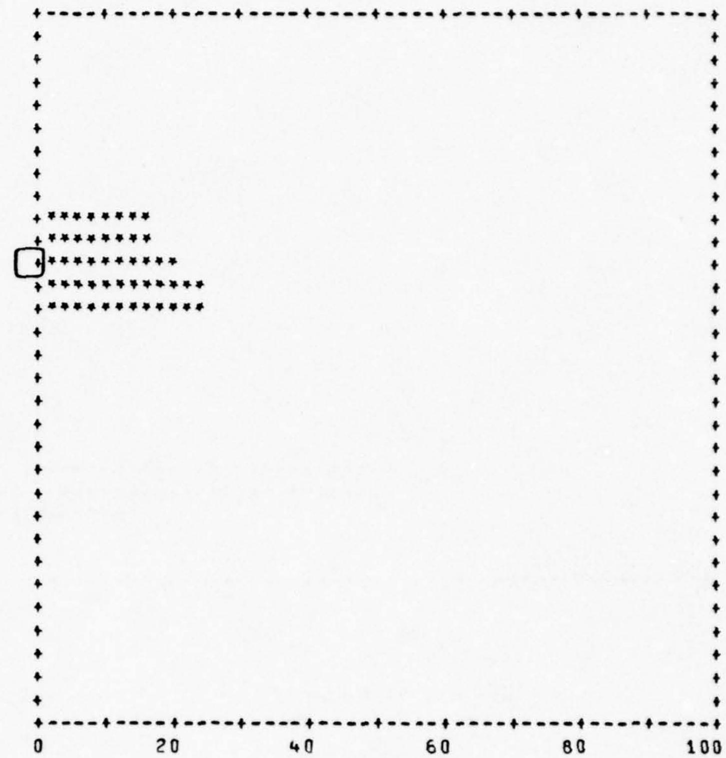
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	1	.040
6 - 7	12	.480
8 - 9	12	.480
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	0	0.000
18 - 19	0	0.000
20 - 21	0	0.000
22 - 23	0	0.000
24 - 25	0	0.000
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMEER OF FATCHES, RETURN FOR RPV 15

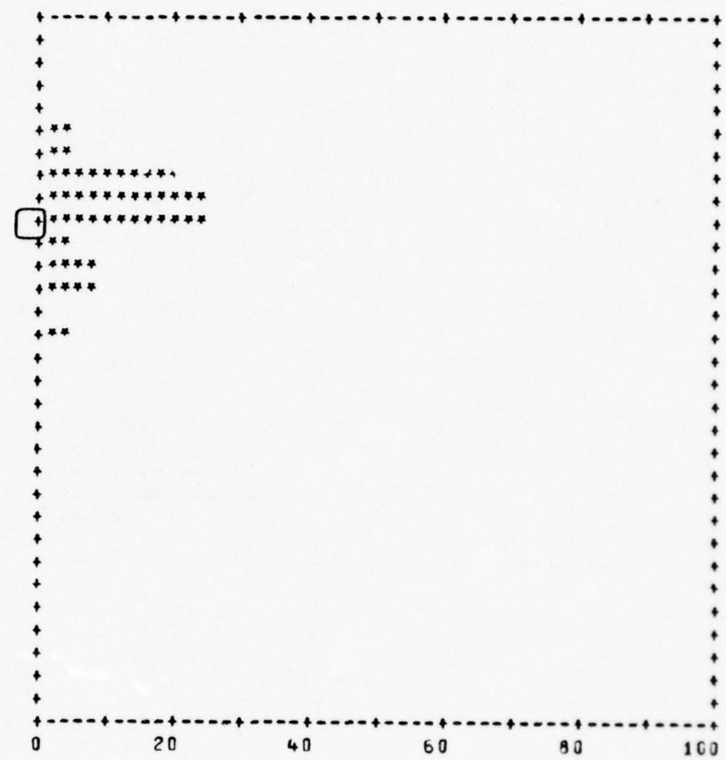
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	0	0.000
6 - 7	0	0.000
8 - 9	0	0.000
10 - 11	0	0.000
12 - 13	0	0.000
14 - 15	0	0.000
16 - 17	4	.160
18 - 19	4	.160
20 - 21	5	.200
22 - 23	6	.240
24 - 25	6	.240
26 - 27	0	0.000
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF PATCHES, RETURN FOR RPV 1C

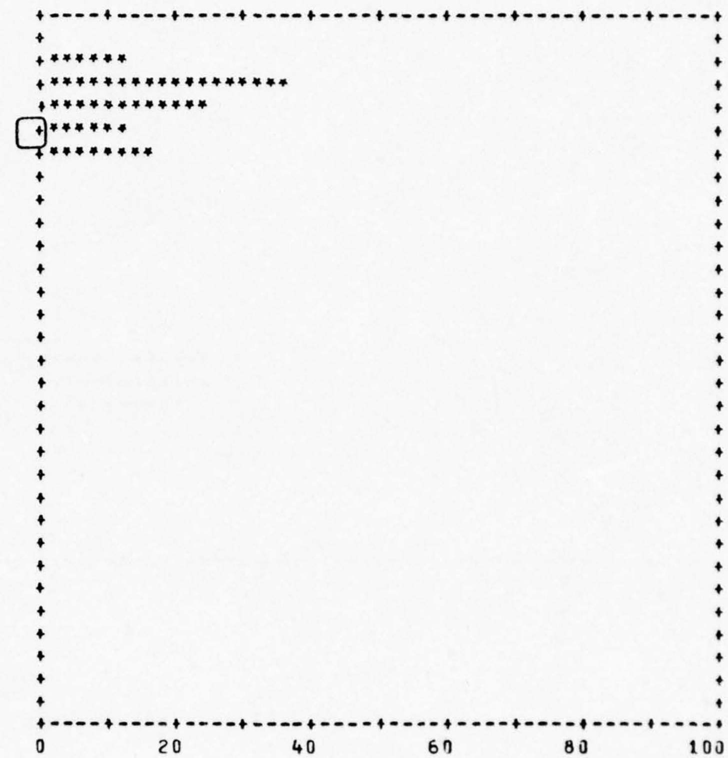
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 1	0	0.000
2 - 3	0	0.000
4 - 5	0	0.000
6 - 7	0	0.000
8 - 9	1	.040
10 - 11	1	.040
12 - 13	5	.200
14 - 15	6	.240
16 - 17	6	.240
18 - 19	1	.040
20 - 21	2	.080
22 - 23	2	.080
24 - 25	0	0.000
26 - 27	1	.040
28 - 29	0	0.000
30 - 31	0	0.000
32 - 33	0	0.000
34 - 35	0	0.000
36 - 37	0	0.000
38 - 39	0	0.000
40 - 41	0	0.000
42 - 43	0	0.000
44 - 45	0	0.000
46 - 47	0	0.000
48 - 49	0	0.000
50 - 51	0	0.000
52 - 53	0	0.000
54 - 55	0	0.000
56 - 57	0	0.000
58 - 59	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, ENROUTE   FOR RPV 1

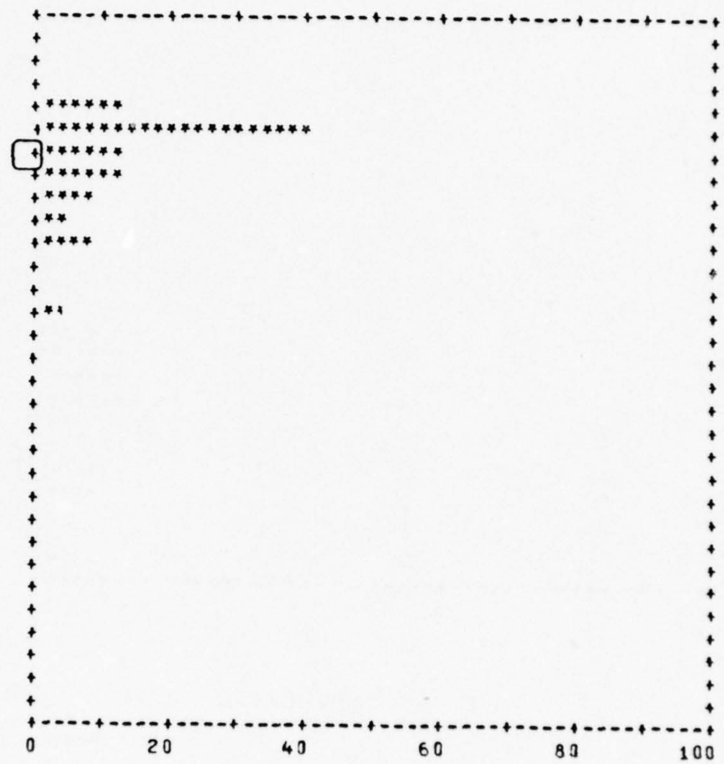
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	3	.120
2 - 2	9	.360
3 - 3	6	.240
4 - 4	3	.120
5 - 5	4	.160
6 - 6	0	0.000
7 - 7	0	0.000
8 - 8	0	0.000
9 - 9	0	0.000
10 - 10	0	0.000
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, ENROUTE FOR RPV 2

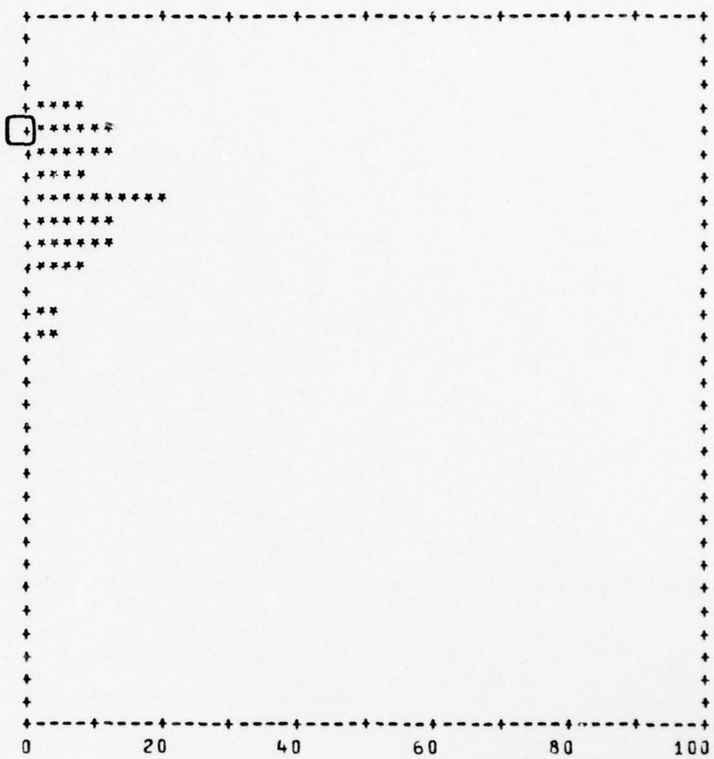
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	0	0.000
2 - 2	0	0.000
3 - 3	3	.120
4 - 4	10	.400
5 - 5	3	.120
6 - 6	3	.120
7 - 7	2	.080
8 - 8	1	.040
9 - 9	2	.080
10 - 10	0	0.000
11 - 11	0	0.000
12 - 12	1	.040
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, ENROUTE FOR RPV 3

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	0	0.000
2 - 2	0	0.000
3 - 3	2	.080
4 - 4	3	.120
5 - 5	3	.120
6 - 6	2	.080
7 - 7	5	.200
8 - 8	3	.120
9 - 9	3	.120
10 - 10	2	.080
11 - 11	0	0.000
12 - 12	1	.040
13 - 13	1	.040
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, ENROUTE FOR RPV 4

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	12	.480
2 - 2	9	.360
3 - 3	2	.080
4 - 4	2	.080
5 - 5	0	0.000
6 - 6	0	0.000
7 - 7	0	0.000
8 - 8	0	0.000
9 - 9	0	0.000
10 - 10	0	0.000
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
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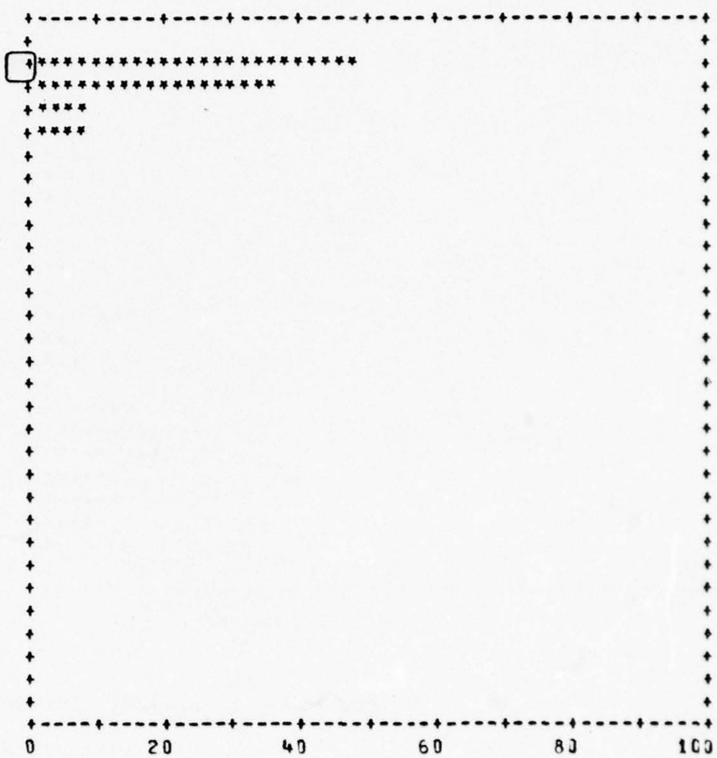
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, ENROUTE FOR RPV 5

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	0	0.000
2 - 2	2	.080
3 - 3	2	.080
4 - 4	2	.080
5 - 5	4	.160
6 - 6	6	.240
7 - 7	3	.120
8 - 8	0	0.000
9 - 9	1	.040
10 - 10	1	.040
11 - 11	3	.120
12 - 12	0	0.000
13 - 13	1	.040
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
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22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
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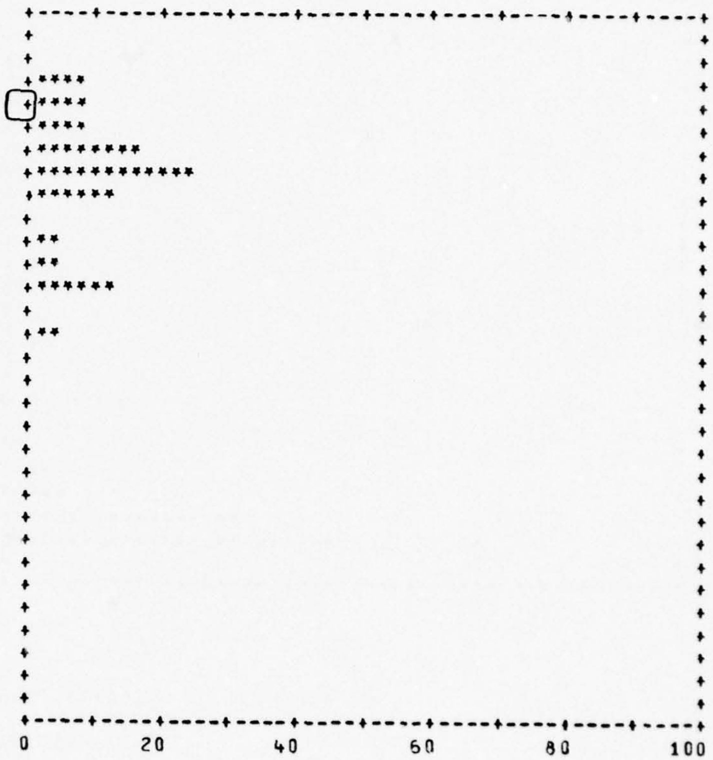
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, ENROUTE FOR PPV 6

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	0	0.000
2 - 2	2	.080
3 - 3	2	.080
4 - 4	2	.080
5 - 5	5	.200
6 - 6	4	.160
7 - 7	3	.120
8 - 8	3	.120
9 - 9	2	.080
10 - 10	1	.040
11 - 11	1	.040
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
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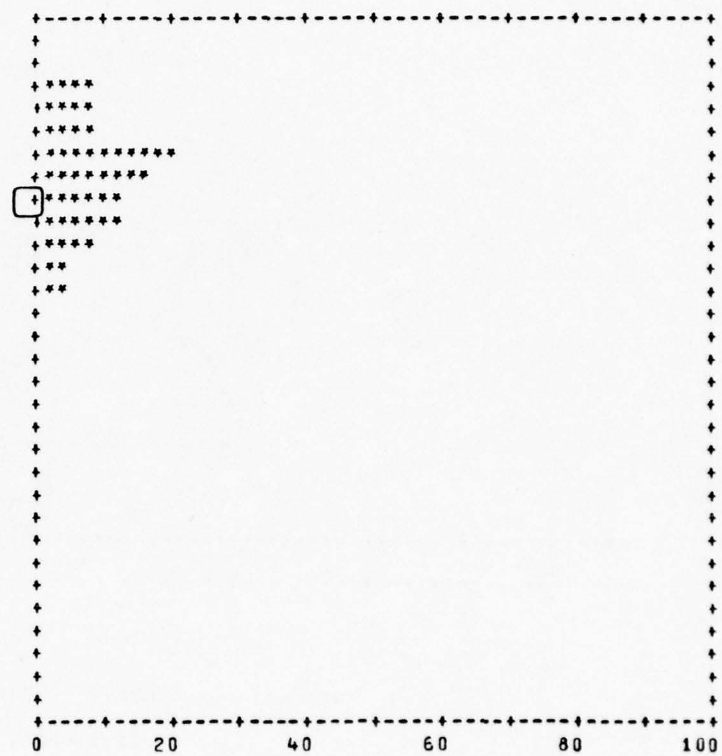
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, ENROUTE FOR RPV 7

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	2	.080
1 - 1	22	.880
2 - 2	1	.040
3 - 3	0	0.000
4 - 4	0	0.000
5 - 5	0	0.000
6 - 6	0	0.000
7 - 7	0	0.000
8 - 8	0	0.000
9 - 9	0	0.000
10 - 10	0	0.000
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
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19 - 19	0	0.000
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22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
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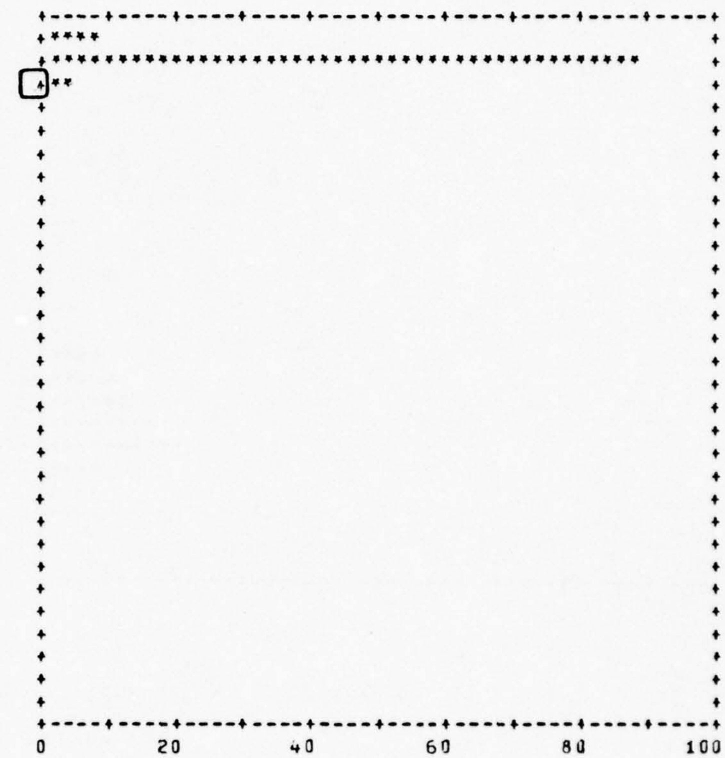
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, ENROUTE FOR RPV 8

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	0	0.000
2 - 2	1	.040
3 - 3	9	.360
4 - 4	2	.080
5 - 5	1	.040
6 - 6	6	.240
7 - 7	2	.080
8 - 8	0	0.000
9 - 9	1	.040
10 - 10	2	.080
11 - 11	0	0.000
12 - 12	1	.040
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
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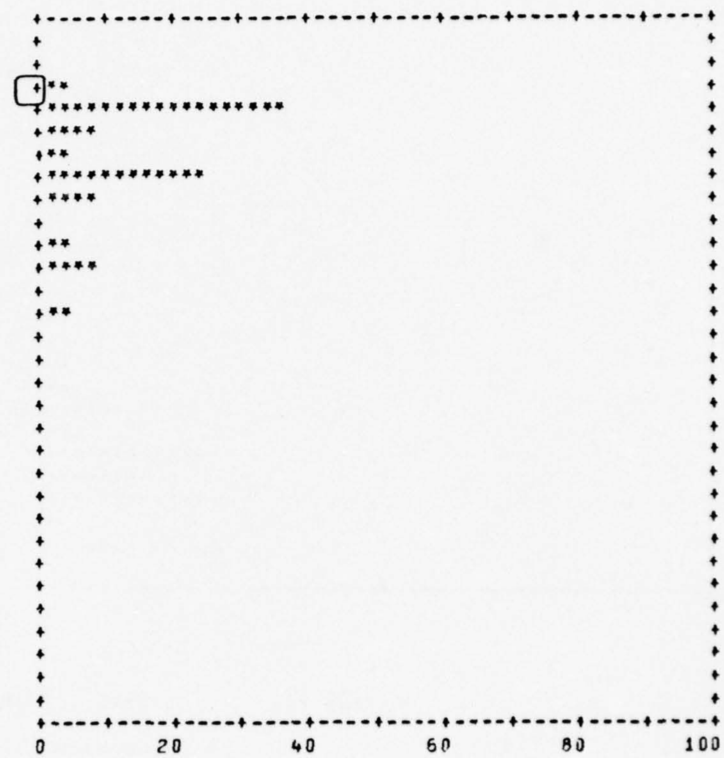
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, ENROUTE FOR RPV 9

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	0	0.000
2 - 2	1	.040
3 - 3	6	.240
4 - 4	4	.160
5 - 5	6	.240
6 - 6	1	.040
7 - 7	3	.120
8 - 8	1	.040
9 - 9	1	.040
10 - 10	1	.040
11 - 11	1	.040
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
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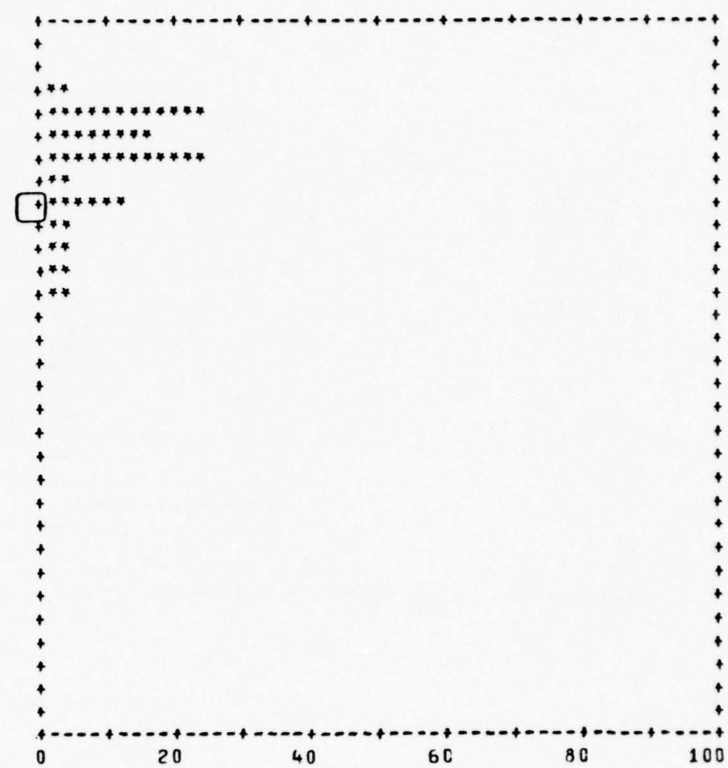
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, ENROUTE FOR RPV 10

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	8	.320
1 - 1	15	.600
2 - 2	2	.080
3 - 3	0	0.000
4 - 4	0	0.000
5 - 5	0	0.000
6 - 6	0	0.000
7 - 7	0	0.000
8 - 8	0	0.000
9 - 9	0	0.000
10 - 10	0	0.000
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
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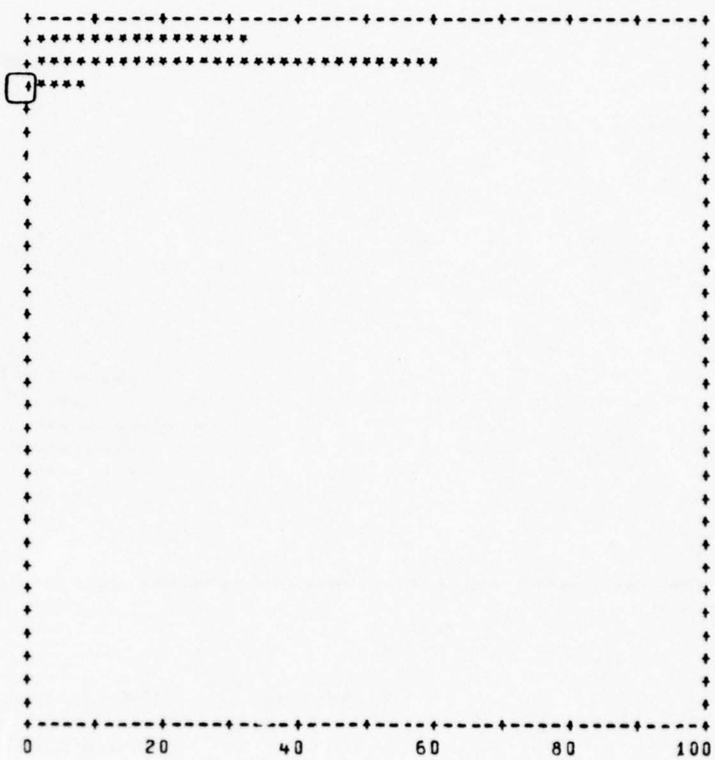
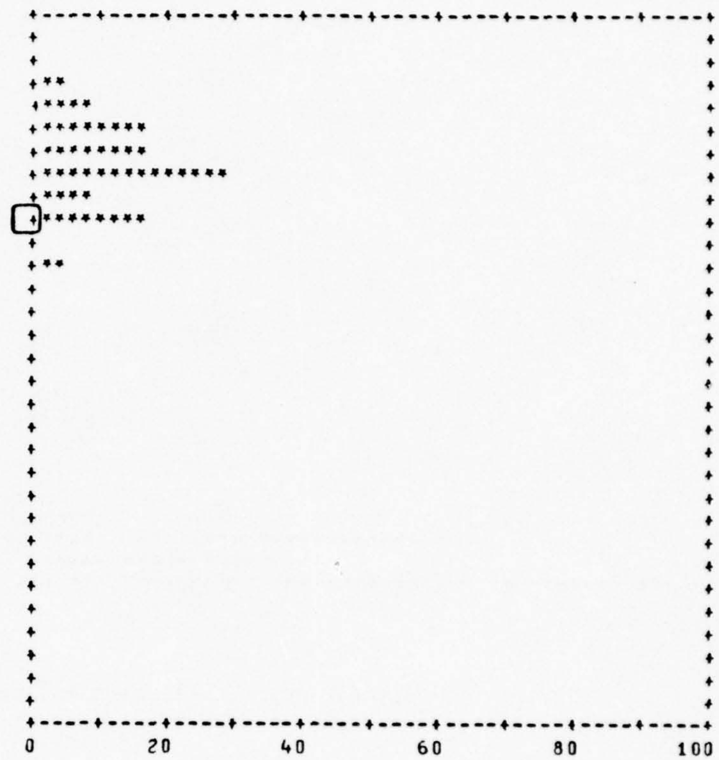
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, ENROUTE FOR RPV 11

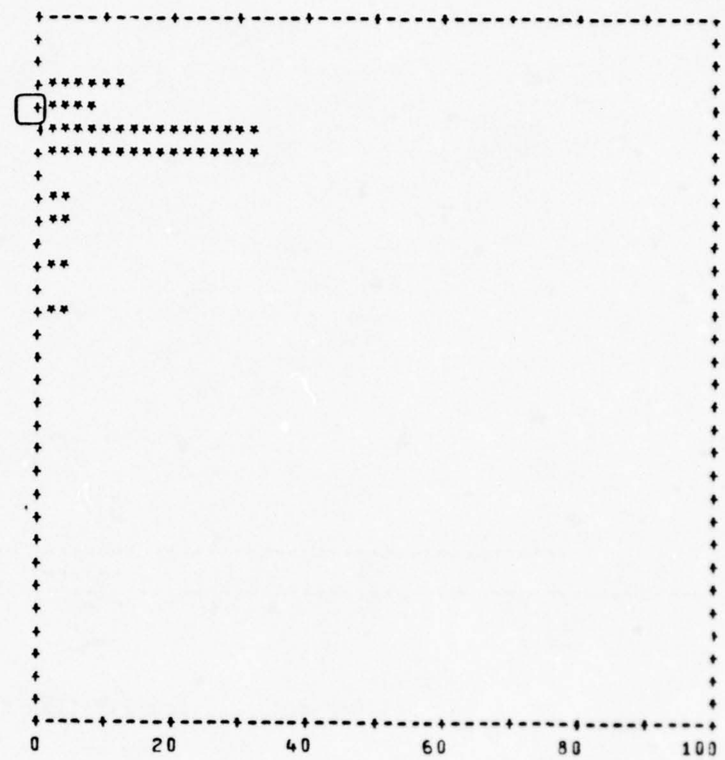
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	0	0.000
2 - 2	1	.040
3 - 3	2	.080
4 - 4	4	.160
5 - 5	4	.160
6 - 6	7	.280
7 - 7	2	.080
8 - 8	4	.160
9 - 9	0	0.000
10 - 10	1	.040
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMEER OF VELOCITY CHANGES, ENROUTE FOR RPV 12

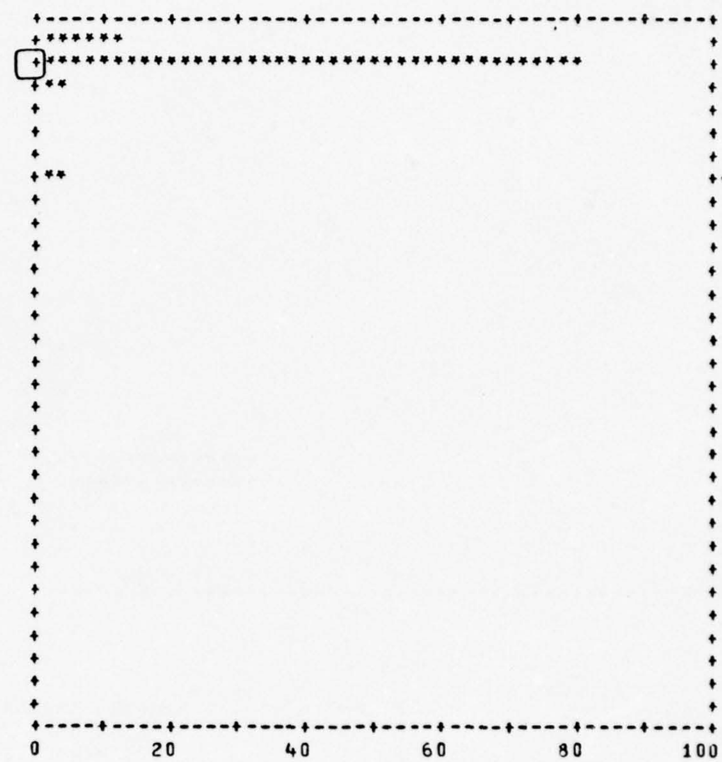
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	0	0.000
2 - 2	3	.120
3 - 3	2	.080
4 - 4	8	.320
5 - 5	8	.320
6 - 6	0	0.000
7 - 7	1	.040
8 - 8	1	.040
9 - 9	0	0.000
10 - 10	1	.040
11 - 11	0	0.000
12 - 12	1	.040
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, ENROUTE FOR RPV 13

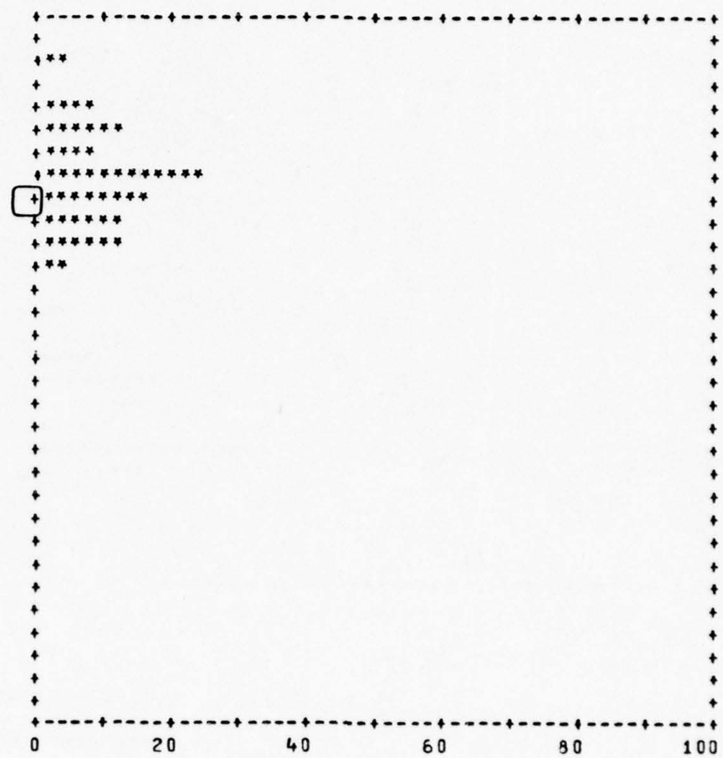
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	3	.120
1 - 1	20	.800
2 - 2	1	.040
3 - 3	0	0.000
4 - 4	0	0.000
5 - 5	0	0.000
6 - 6	1	.040
7 - 7	0	0.000
8 - 8	0	0.000
9 - 9	0	0.000
10 - 10	0	0.000
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, ENROUTE FOR RPV 14

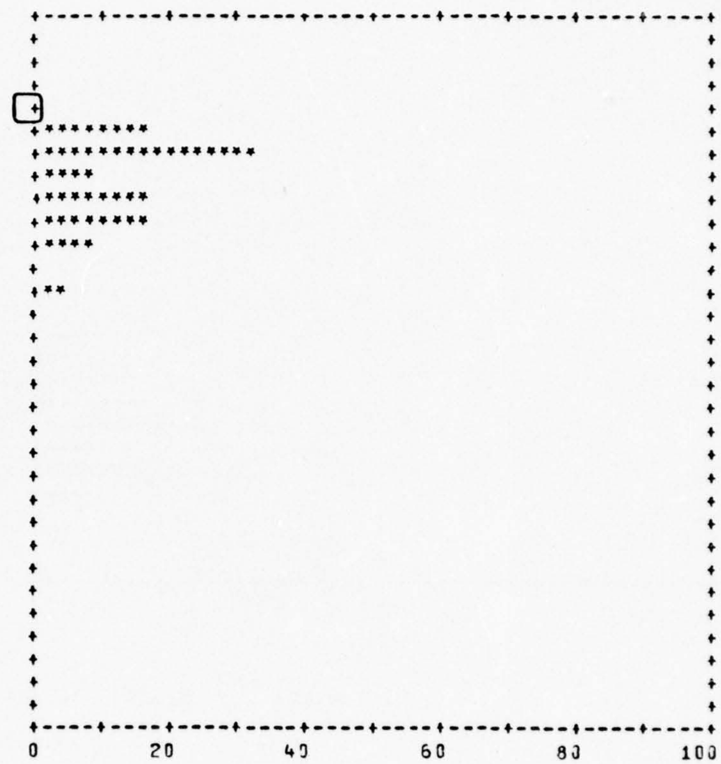
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	1	.040
2 - 2	0	0.000
3 - 3	2	.080
4 - 4	3	.120
5 - 5	2	.080
6 - 6	6	.240
7 - 7	4	.160
8 - 8	3	.120
9 - 9	3	.120
10 - 10	1	.040
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, ENROUTE   FOR RPV 15

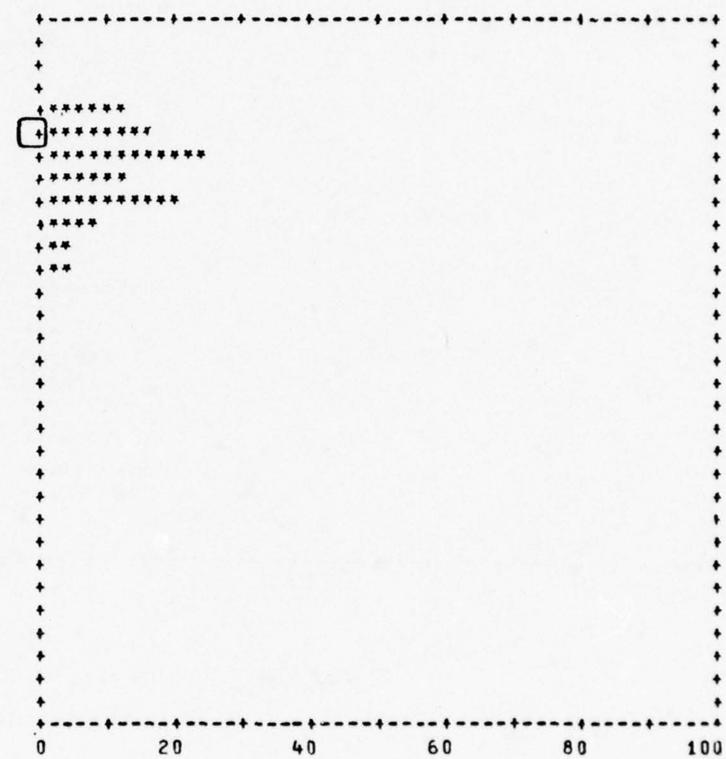
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	0	0.000
2 - 2	0	0.000
3 - 3	0	0.000
4 - 4	4	.160
5 - 5	8	.320
6 - 6	2	.080
7 - 7	4	.160
8 - 8	4	.160
9 - 9	2	.080
10 - 10	0	0.000
11 - 11	1	.040
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, ENROUTE FOR RPV 16

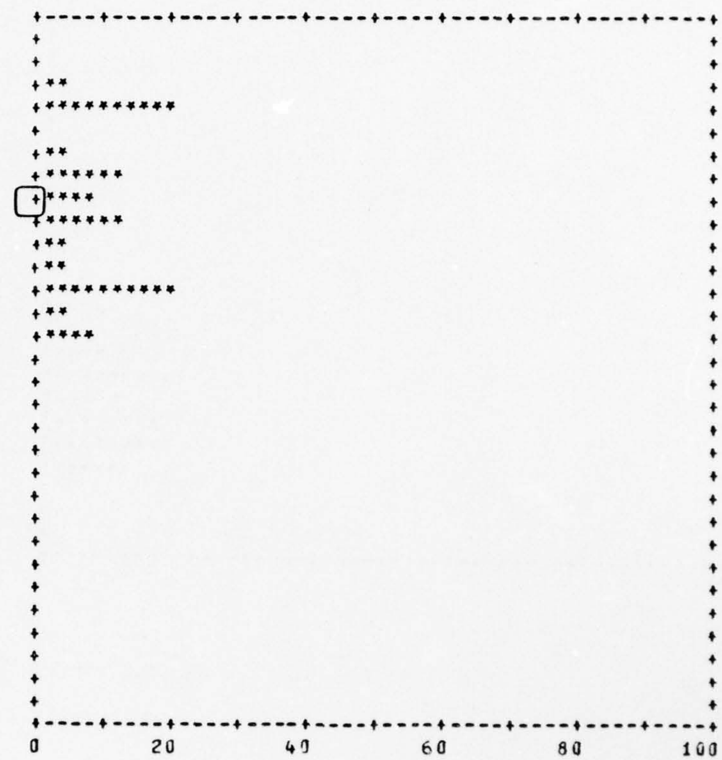
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	0	0.000
2 - 2	0	0.000
3 - 3	3	.120
4 - 4	4	.160
5 - 5	6	.240
6 - 6	3	.120
7 - 7	5	.200
8 - 8	2	.080
9 - 9	1	.040
10 - 10	1	.040
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, RETURN FOR RPV 1

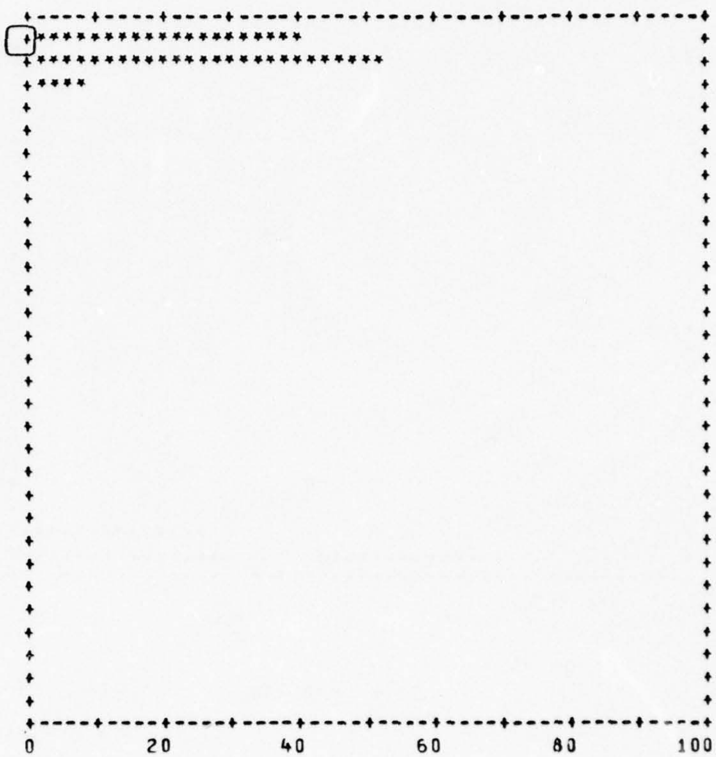
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	0	0.000
2 - 2	1	.040
3 - 3	5	.200
4 - 4	0	0.000
5 - 5	1	.040
6 - 6	3	.120
7 - 7	2	.080
8 - 8	3	.120
9 - 9	1	.040
10 - 10	1	.040
11 - 11	5	.200
12 - 12	1	.040
13 - 13	2	.080
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, RETURN FOR RPV 2

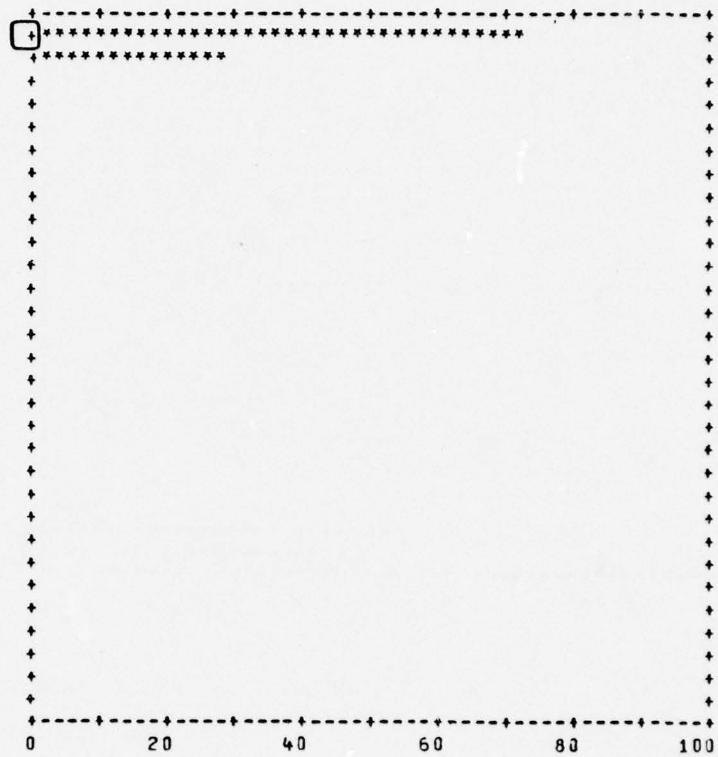
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	10	.400
1 - 1	13	.520
2 - 2	2	.080
3 - 3	0	0.000
4 - 4	0	0.000
5 - 5	0	0.000
6 - 6	0	0.000
7 - 7	0	0.000
8 - 8	0	0.000
9 - 9	0	0.000
10 - 10	0	0.000
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBEF OF VELOCITY CHANGES, RETURN FOR RPV 3

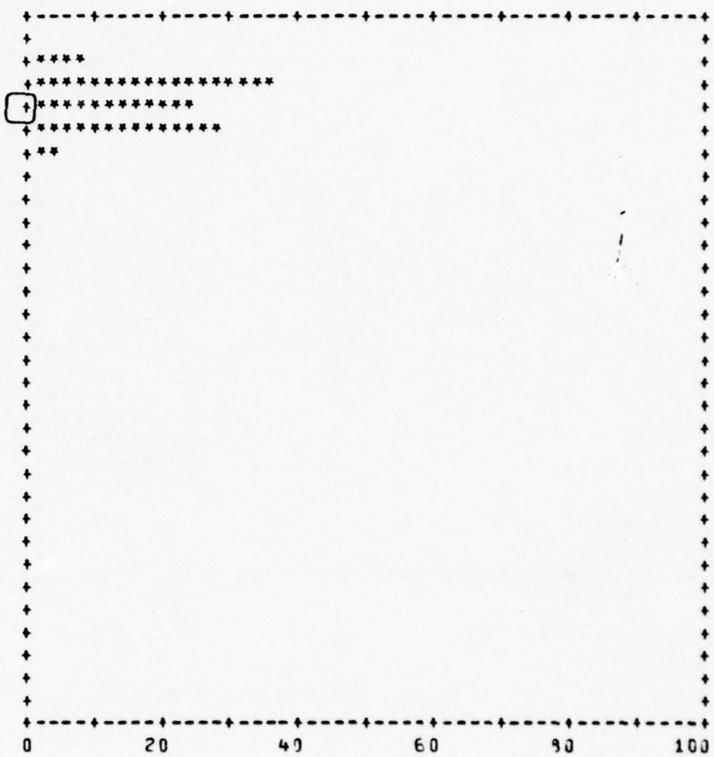
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	18	.720
1 - 1	7	.280
2 - 2	0	0.000
3 - 3	0	0.000
4 - 4	0	0.000
5 - 5	0	0.000
6 - 6	0	0.000
7 - 7	0	0.000
8 - 8	0	0.000
9 - 9	0	0.000
10 - 10	0	0.000
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, RETURN FOR RPV 4

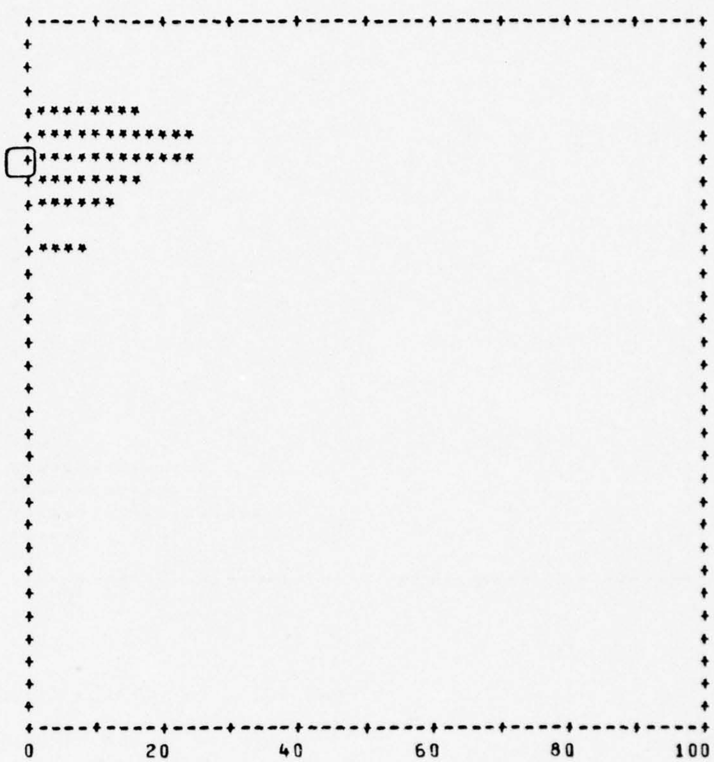
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	2	.080
2 - 2	9	.360
3 - 3	6	.240
4 - 4	7	.280
5 - 5	1	.040
6 - 6	0	0.000
7 - 7	0	0.000
8 - 8	0	0.000
9 - 9	0	0.000
10 - 10	0	0.000
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, RETURN FOR RPV 5

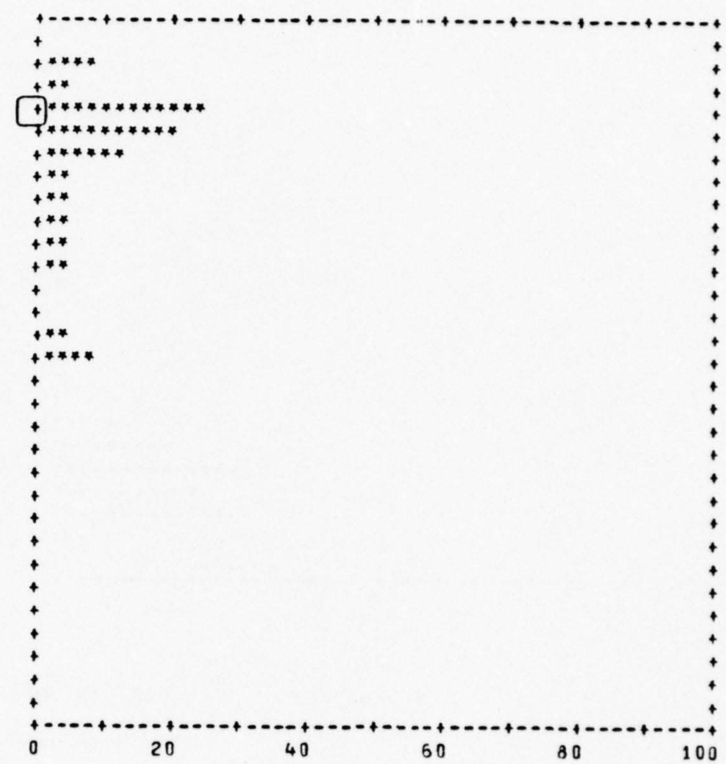
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	0	0.000
2 - 2	0	0.000
3 - 3	4	.160
4 - 4	6	.240
5 - 5	6	.240
6 - 6	4	.160
7 - 7	3	.120
8 - 8	0	0.000
9 - 9	2	.080
10 - 10	0	0.000
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, RETURN FOR RPV 6

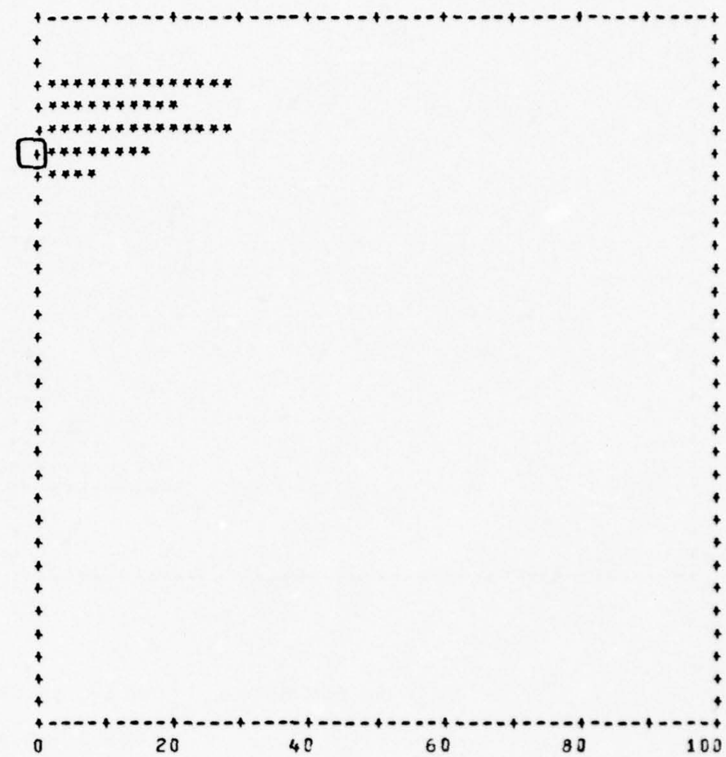
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	2	.080
2 - 2	1	.040
3 - 3	6	.240
4 - 4	5	.200
5 - 5	3	.120
6 - 6	1	.040
7 - 7	1	.040
8 - 8	1	.040
9 - 9	1	.040
10 - 10	1	.040
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	1	.040
14 - 14	2	.080
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, RETURN FOR RPV 7

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	0	0.000
2 - 2	7	.280
3 - 3	5	.200
4 - 4	7	.280
5 - 5	4	.160
6 - 6	2	.080
7 - 7	0	0.000
8 - 8	0	0.000
9 - 9	0	0.000
10 - 10	0	0.000
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

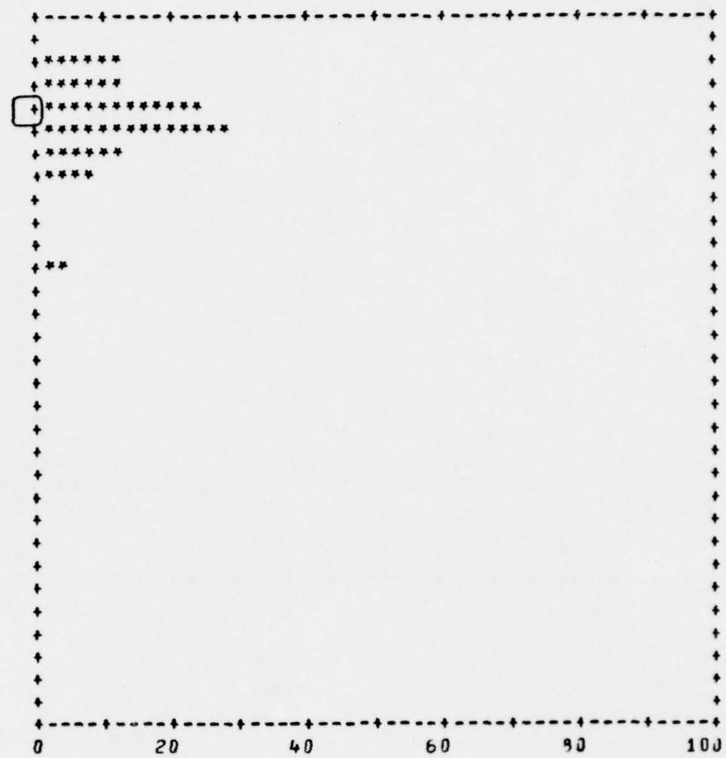
NUMEER OF VELCCITY CHANGES, RETURN FOR RPV 8

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	1	.040
2 - 2	3	.120
3 - 3	7	.280
4 - 4	5	.200
5 - 5	2	.080
6 - 6	3	.120
7 - 7	2	.080
8 - 8	2	.080
9 - 9	0	0.000
10 - 10	0	0.000
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000

HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, RETURN FOR RPV 9

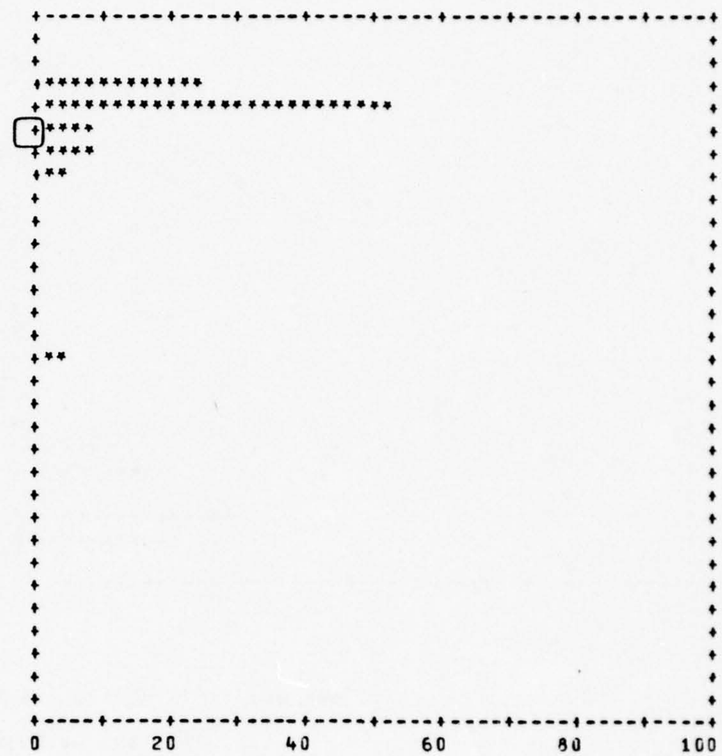
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	3	.120
2 - 2	3	.120
3 - 3	6	.240
4 - 4	7	.280
5 - 5	3	.120
6 - 6	2	.080
7 - 7	0	0.000
8 - 8	0	0.000
9 - 9	0	0.000
10 - 10	1	.040
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, RETURN FOR RPV 10

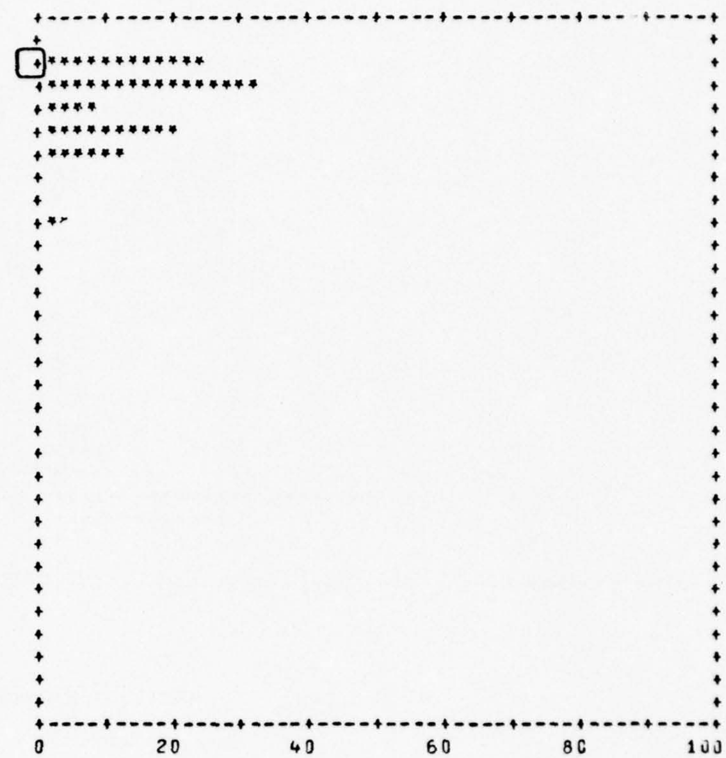
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	0	0.000
2 - 2	6	.240
3 - 3	13	.520
4 - 4	2	.080
5 - 5	2	.080
6 - 6	1	.040
7 - 7	0	0.000
8 - 8	0	0.000
9 - 9	0	0.000
10 - 10	0	0.000
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	1	.040
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, RETURN FOR RPV 11

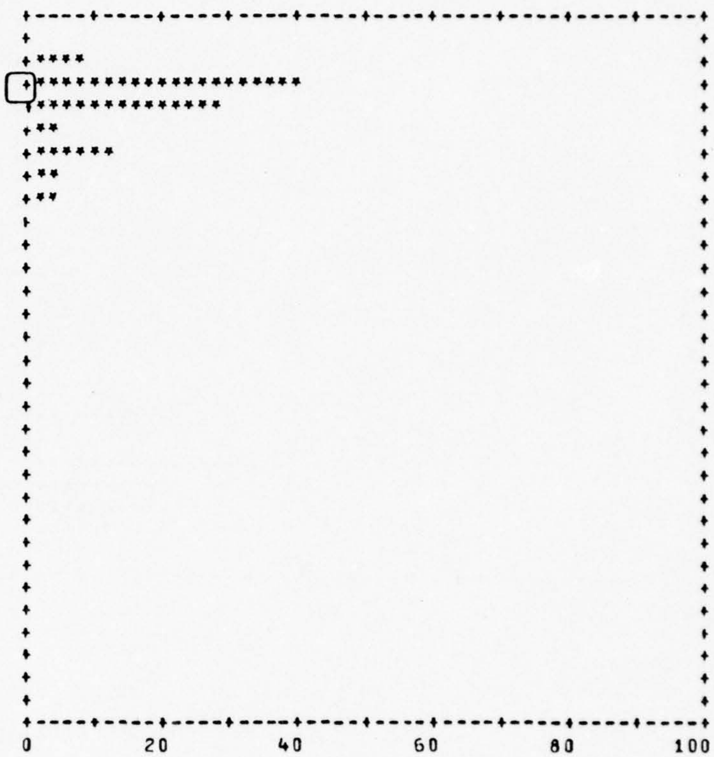
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	6	.240
2 - 2	8	.320
3 - 3	2	.080
4 - 4	5	.200
5 - 5	3	.120
6 - 6	0	0.000
7 - 7	0	0.000
8 - 8	1	.040
9 - 9	0	0.000
10 - 10	0	0.000
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, RETURN FOR RPV 12

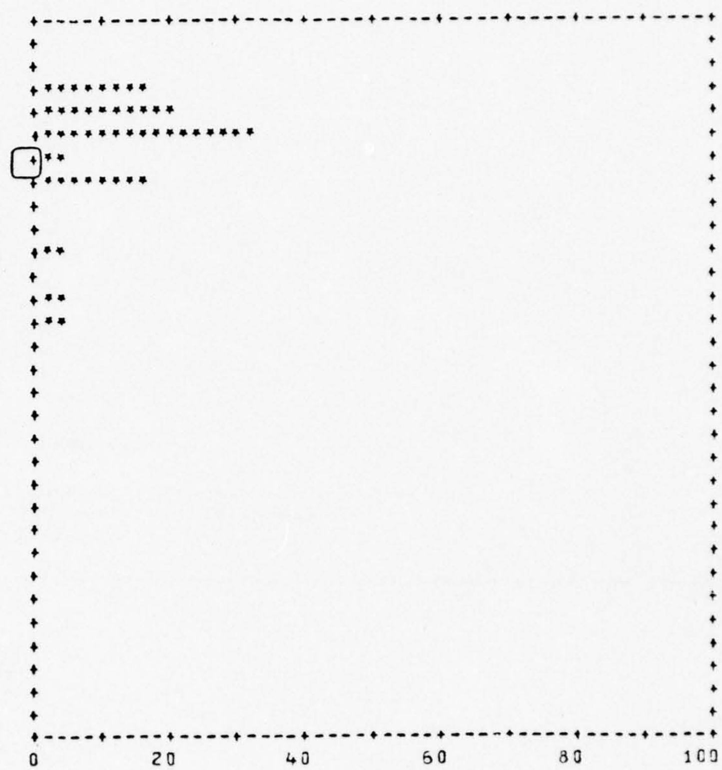
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	2	.080
2 - 2	10	.400
3 - 3	7	.280
4 - 4	1	.040
5 - 5	3	.120
6 - 6	1	.040
7 - 7	1	.040
8 - 8	0	0.000
9 - 9	0	0.000
10 - 10	0	0.000
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, RETURN FOR RPV 13

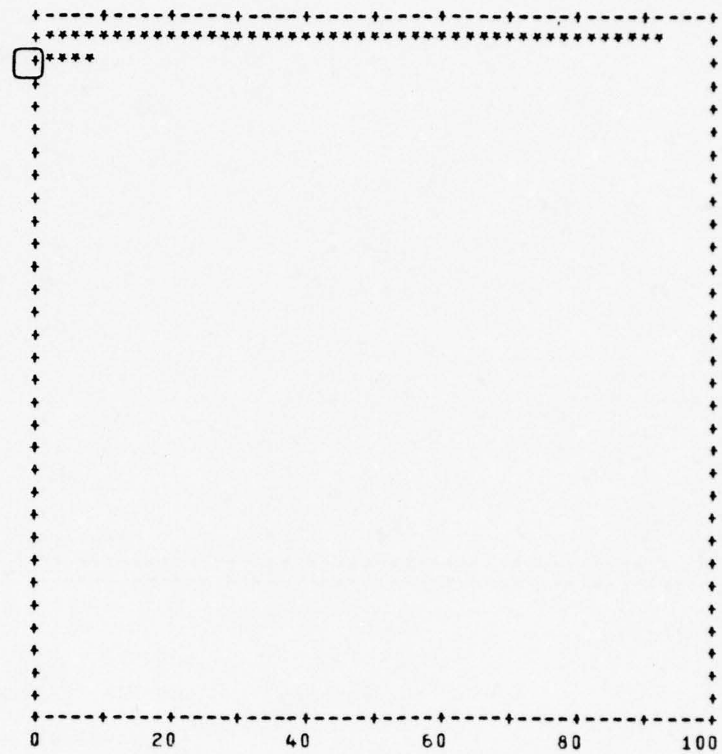
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	0	0.000
2 - 2	4	.160
3 - 3	5	.200
4 - 4	8	.320
5 - 5	1	.040
6 - 6	4	.160
7 - 7	0	0.000
8 - 8	0	0.000
9 - 9	1	.040
10 - 10	0	0.000
11 - 11	1	.040
12 - 12	1	.040
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMEER OF VELCCITY CHANGES, RETURN FOR RPV 14

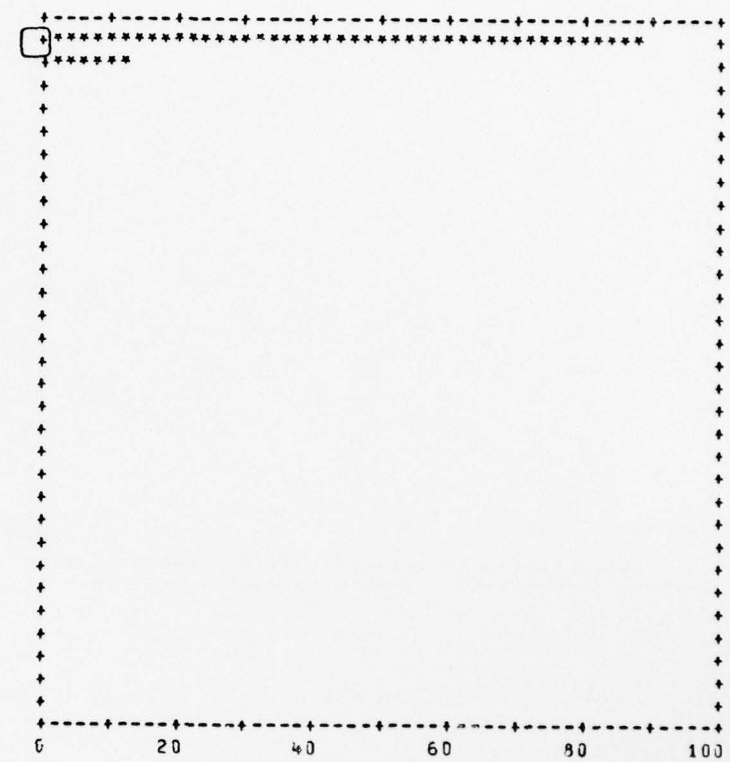
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	23	.920
1 - 1	2	.080
2 - 2	0	0.000
3 - 3	0	0.000
4 - 4	0	0.000
5 - 5	0	0.000
6 - 6	0	0.000
7 - 7	0	0.000
8 - 8	0	0.000
9 - 9	0	0.000
10 - 10	0	0.000
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMEER OF VELOCITY CHANGES, RETURN FOR RPV 15

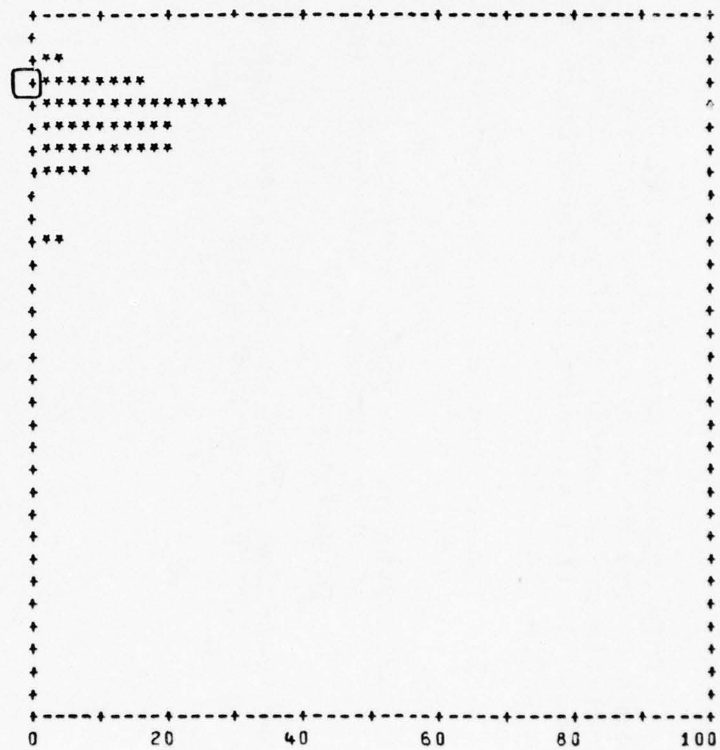
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	22	.880
1 - 1	3	.120
2 - 2	0	0.000
3 - 3	0	0.000
4 - 4	0	0.000
5 - 5	0	0.000
6 - 6	0	0.000
7 - 7	0	0.000
8 - 8	0	0.000
9 - 9	0	0.000
10 - 10	0	0.000
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



HISTOGRAM FOR

NUMBER OF VELOCITY CHANGES, RETURN FOR RPV 16

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
0 - 0	0	0.000
1 - 1	1	.040
2 - 2	4	.160
3 - 3	7	.280
4 - 4	5	.200
5 - 5	5	.200
6 - 6	2	.080
7 - 7	0	0.000
8 - 8	0	0.000
9 - 9	1	.040
10 - 10	0	0.000
11 - 11	0	0.000
12 - 12	0	0.000
13 - 13	0	0.000
14 - 14	0	0.000
15 - 15	0	0.000
16 - 16	0	0.000
17 - 17	0	0.000
18 - 18	0	0.000
19 - 19	0	0.000
20 - 20	0	0.000
21 - 21	0	0.000
22 - 22	0	0.000
23 - 23	0	0.000
24 - 24	0	0.000
25 - 25	0	0.000
26 - 26	0	0.000
27 - 27	0	0.000
28 - 28	0	0.000
29 - 29	0	0.000



APPENDIX II

HISTOGRAMS FOR COMMAND PROCESSING STATISTICS

This appendix presents the histograms for selected command processing statistics used for the validation analysis presented in Section IV. The histograms that appear in this appendix are listed below in the order in which they appear:

1) Time of the pop-up maneuver for each of the 16 RPVs

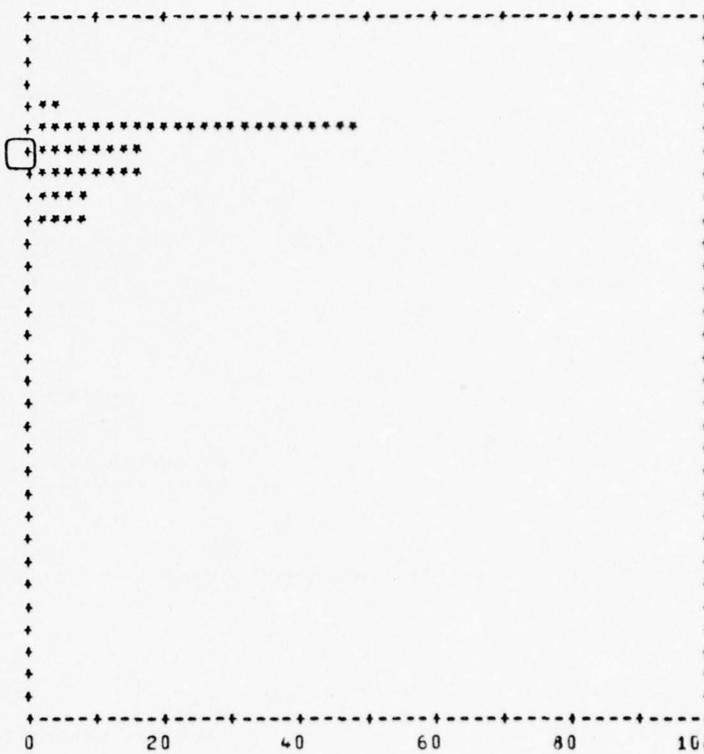
2) Time of the pop-down maneuver for each of the 15 RPVs that were popped-down (RPV 3 was not popped-down).

The real-time values for these variables are indicated by a "□" on these histograms.

HISTOGRAM FOR

TIME OF POP-UP MANEUVER FOR RPV 1

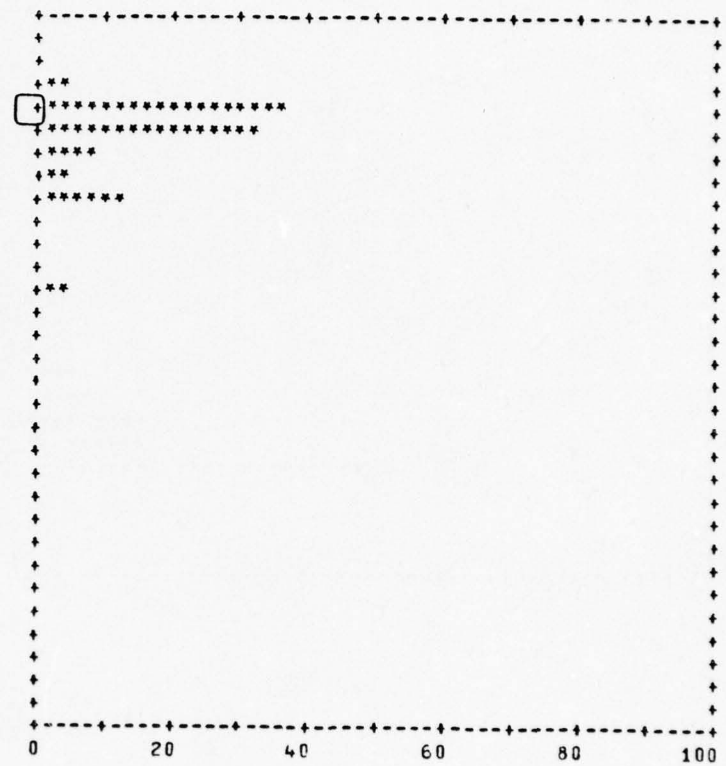
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
1750 - 1755	0	0.000
1760 - 1765	0	0.000
1770 - 1775	0	0.000
1780 - 1785	1	.040
1790 - 1795	12	.480
1800 - 1805	4	.160
1810 - 1815	4	.160
1820 - 1825	2	.080
1830 - 1835	2	.080
1840 - 1845	0	0.000
1850 - 1855	0	0.000
1860 - 1865	0	0.000
1870 - 1875	0	0.000
1880 - 1885	0	0.000
1890 - 1895	0	0.000
1900 - 1905	0	0.000
1910 - 1915	0	0.000
1920 - 1925	0	0.000
1930 - 1935	0	0.000
1940 - 1945	0	0.000
1950 - 1955	0	0.000
1960 - 1965	0	0.000
1970 - 1975	0	0.000
1980 - 1985	0	0.000
1990 - 1995	0	0.000
2000 - 2005	0	0.000
2010 - 2015	0	0.000
2020 - 2025	0	0.000
2030 - 2035	0	0.000
2040 - 2045	0	0.000



HISTOGRAM FOR

TIME OF POP-UP MANEUVER FOR RPV 2

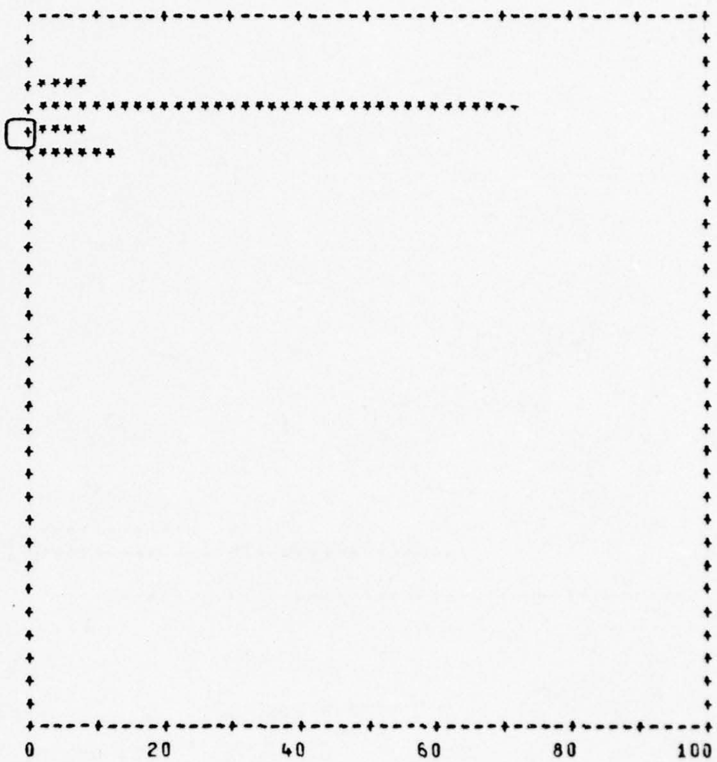
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
1900 - 1905	0	0.000
1910 - 1915	0	0.000
1920 - 1925	1	.040
1930 - 1935	9	.360
1940 - 1945	8	.320
1950 - 1955	2	.080
1960 - 1965	1	.040
1970 - 1975	3	.120
1980 - 1985	0	0.000
1990 - 1995	0	0.000
2000 - 2005	0	0.000
2010 - 2015	1	.040
2020 - 2025	0	0.000
2030 - 2035	0	0.000
2040 - 2045	0	0.000
2050 - 2055	0	0.000
2060 - 2065	0	0.000
2070 - 2075	0	0.000
2080 - 2085	0	0.000
2090 - 2095	0	0.000
2100 - 2105	0	0.000
2110 - 2115	0	0.000
2120 - 2125	0	0.000
2130 - 2135	0	0.000
2140 - 2145	0	0.000
2150 - 2155	0	0.000
2160 - 2165	0	0.000
2170 - 2175	0	0.000
2180 - 2185	0	0.000
2190 - 2195	0	0.000



HISTOGRAM FOR

TIME OF POP-UP MANEUVER FOR RPV 3

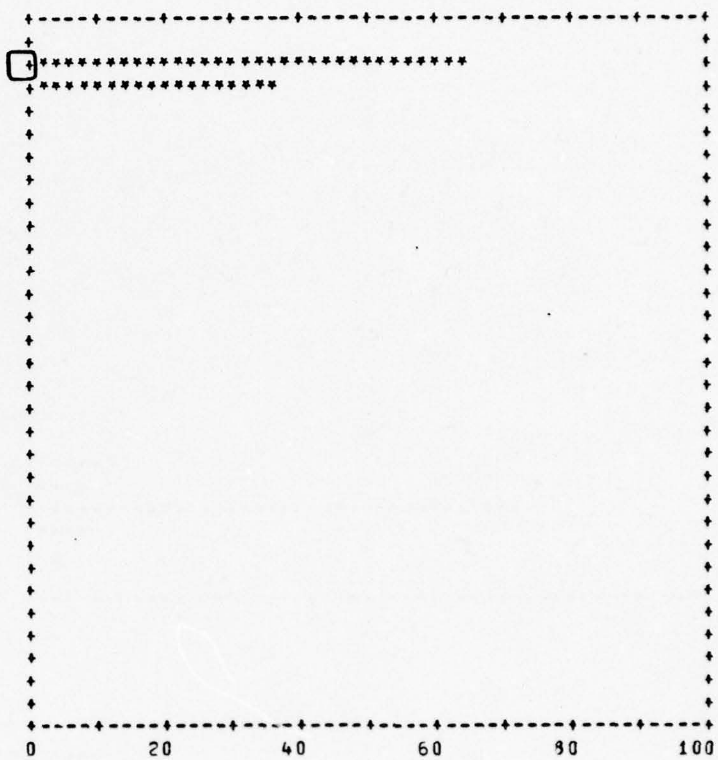
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2000 - 2005	0	0.000
2010 - 2015	0	0.000
2020 - 2025	2	.080
2030 - 2035	18	.720
2040 - 2045	2	.080
2050 - 2055	3	.120
2060 - 2065	0	0.000
2070 - 2075	0	0.000
2080 - 2085	0	0.000
2090 - 2095	0	0.000
2100 - 2105	0	0.000
2110 - 2115	0	0.000
2120 - 2125	0	0.000
2130 - 2135	0	0.000
2140 - 2145	0	0.000
2150 - 2155	0	0.000
2160 - 2165	0	0.000
2170 - 2175	0	0.000
2180 - 2185	0	0.000
2190 - 2195	0	0.000
2200 - 2205	0	0.000
2210 - 2215	0	0.000
2220 - 2225	0	0.000
2230 - 2235	0	0.000
2240 - 2245	0	0.000
2250 - 2255	0	0.000
2260 - 2265	0	0.000
2270 - 2275	0	0.000
2280 - 2285	0	0.000
2290 - 2295	0	0.000



HISTOGRAM FOR

TIME OF POP-UP MANEUVER FOR RPV 4

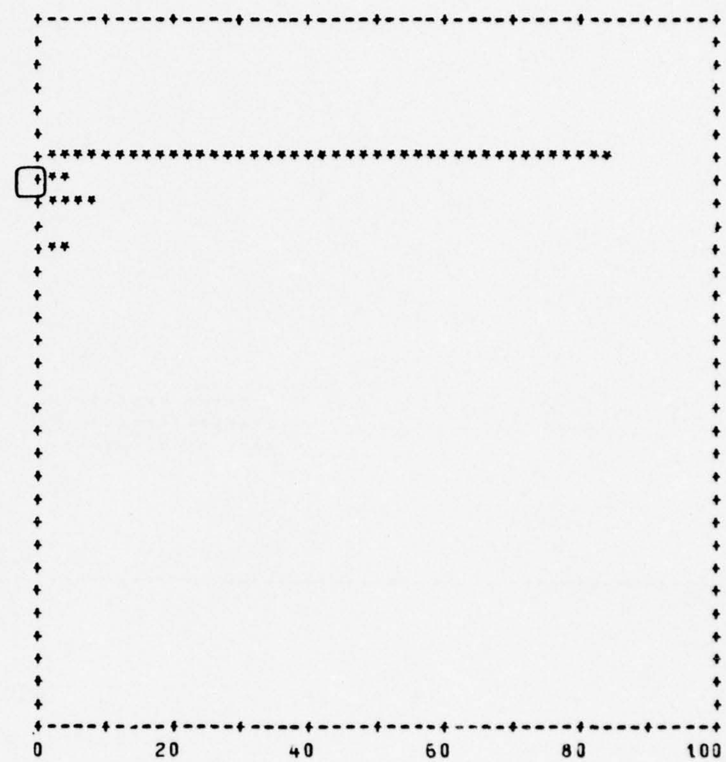
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
1850 - 1855	0	0.000
1860 - 1865	16	.640
1870 - 1875	9	.360
1880 - 1885	0	0.000
1890 - 1895	0	0.000
1900 - 1905	0	0.000
1910 - 1915	0	0.000
1920 - 1925	0	0.000
1930 - 1935	0	0.000
1940 - 1945	0	0.000
1950 - 1955	0	0.000
1960 - 1965	0	0.000
1970 - 1975	0	0.000
1980 - 1985	0	0.000
1990 - 1995	0	0.000
2000 - 2005	0	0.000
2010 - 2015	0	0.000
2020 - 2025	0	0.000
2030 - 2035	0	0.000
2040 - 2045	0	0.000
2050 - 2055	0	0.000
2060 - 2065	0	0.000
2070 - 2075	0	0.000
2080 - 2085	0	0.000
2090 - 2095	0	0.000
2100 - 2105	0	0.000
2110 - 2115	0	0.000
2120 - 2125	0	0.000
2130 - 2135	0	0.000
2140 - 2145	0	0.000



HISTOGRAM FOR

TIME OF POP-UP MANEUVER FOR RPV 5

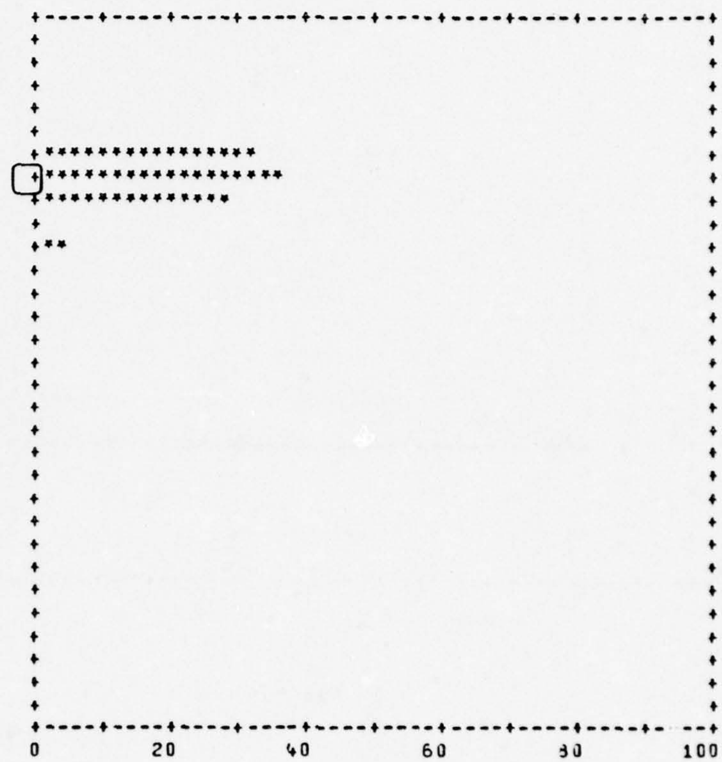
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
1950 - 1955	0	0.000
1960 - 1965	0	0.000
1970 - 1975	0	0.000
1980 - 1985	0	0.000
1990 - 1995	0	0.000
2000 - 2005	21	.840
2010 - 2015	1	.040
2020 - 2025	2	.080
2030 - 2035	0	0.000
2040 - 2045	1	.040
2050 - 2055	0	0.000
2060 - 2065	0	0.000
2070 - 2075	0	0.000
2080 - 2085	0	0.000
2090 - 2095	0	0.000
2100 - 2105	0	0.000
2110 - 2115	0	0.000
2120 - 2125	0	0.000
2130 - 2135	0	0.000
2140 - 2145	0	0.000
2150 - 2155	0	0.000
2160 - 2165	0	0.000
2170 - 2175	0	0.000
2180 - 2185	0	0.000
2190 - 2195	0	0.000
2200 - 2205	0	0.000
2210 - 2215	0	0.000
2220 - 2225	0	0.000
2230 - 2235	0	0.000
2240 - 2245	0	0.000



HISTOGRAM FOR

TIME OF POP-UP MANEUVER FOR RPV 6

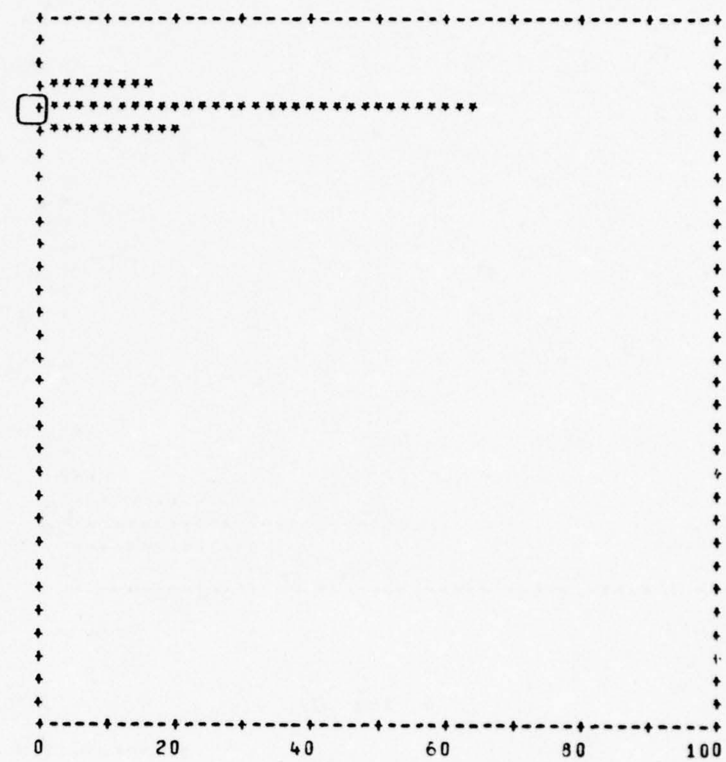
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2050 - 2055	0	0.000
2060 - 2065	0	0.000
2070 - 2075	0	0.000
2080 - 2085	0	0.000
2090 - 2095	0	0.000
2100 - 2105	8	.320
2110 - 2115	9	.360
2120 - 2125	7	.280
2130 - 2135	0	0.000
2140 - 2145	1	.040
2150 - 2155	0	0.000
2160 - 2165	0	0.000
2170 - 2175	0	0.000
2180 - 2185	0	0.000
2190 - 2195	0	0.000
2200 - 2205	0	0.000
2210 - 2215	0	0.000
2220 - 2225	0	0.000
2230 - 2235	0	0.000
2240 - 2245	0	0.000
2250 - 2255	0	0.000
2260 - 2265	0	0.000
2270 - 2275	0	0.000
2280 - 2285	0	0.000
2290 - 2295	0	0.000
2300 - 2305	0	0.000
2310 - 2315	0	0.000
2320 - 2325	0	0.000
2330 - 2335	0	0.000
2340 - 2345	0	0.000



HISTOGRAM FOR

TIME OF POP-UP MANEUVER FOR RPV 7

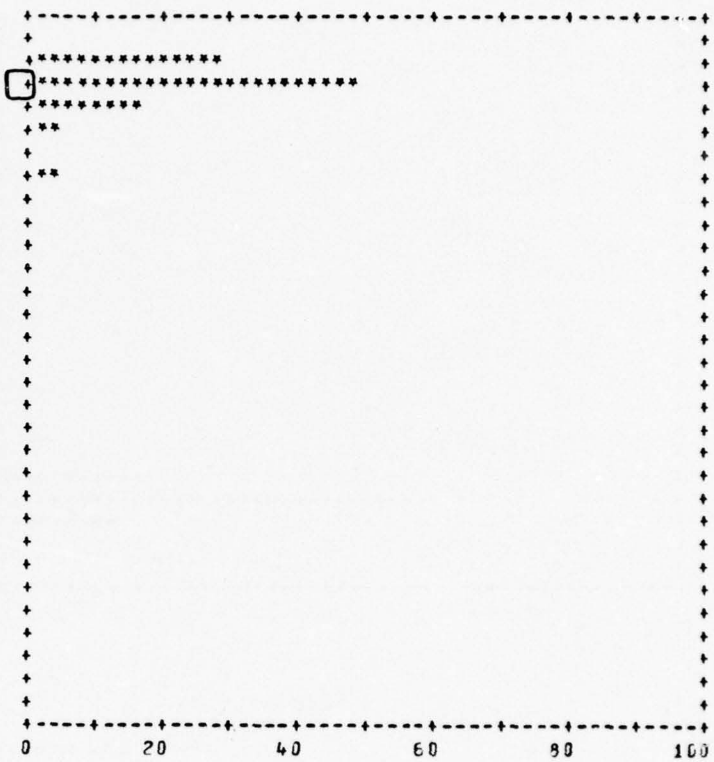
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2100 - 2105	0	0.000
2110 - 2115	0	0.000
2120 - 2125	4	.160
2130 - 2135	16	.640
2140 - 2145	5	.200
2150 - 2155	0	0.000
2160 - 2165	0	0.000
2170 - 2175	0	0.000
2180 - 2185	0	0.000
2190 - 2195	0	0.000
2200 - 2205	0	0.000
2210 - 2215	0	0.000
2220 - 2225	0	0.000
2230 - 2235	0	0.000
2240 - 2245	0	0.000
2250 - 2255	0	0.000
2260 - 2265	0	0.000
2270 - 2275	0	0.000
2280 - 2285	0	0.000
2290 - 2295	0	0.000
2300 - 2305	0	0.000
2310 - 2315	0	0.000
2320 - 2325	0	0.000
2330 - 2335	0	0.000
2340 - 2345	0	0.000
2350 - 2355	0	0.000
2360 - 2365	0	0.000
2370 - 2375	0	0.000
2380 - 2385	0	0.000
2390 - 2395	0	0.000



HISTOGRAM FOR

TIME OF POP-UP MANEUVER FOR RPV 8

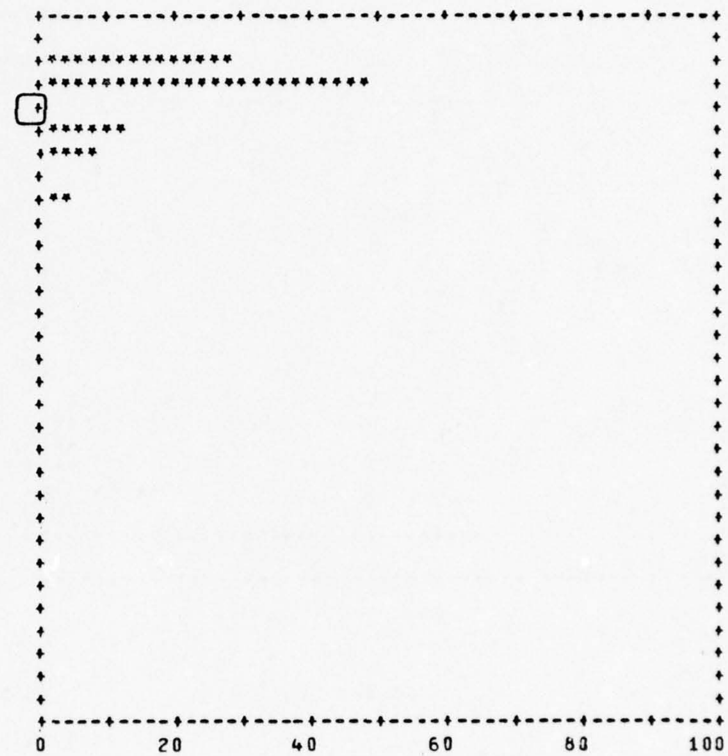
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2250 - 2255	0	0.000
2260 - 2265	7	.280
2270 - 2275	12	.480
2280 - 2285	4	.160
2290 - 2295	1	.040
2300 - 2305	0	0.000
2310 - 2315	1	.040
2320 - 2325	0	0.000
2330 - 2335	0	0.000
2340 - 2345	0	0.000
2350 - 2355	0	0.000
2360 - 2365	0	0.000
2370 - 2375	0	0.000
2380 - 2385	0	0.000
2390 - 2395	0	0.000
2400 - 2405	0	0.000
2410 - 2415	0	0.000
2420 - 2425	0	0.000
2430 - 2435	0	0.000
2440 - 2445	0	0.000
2450 - 2455	0	0.000
2460 - 2465	0	0.000
2470 - 2475	0	0.000
2480 - 2485	0	0.000
2490 - 2495	0	0.000
2500 - 2505	0	0.000
2510 - 2515	0	0.000
2520 - 2525	0	0.000
2530 - 2535	0	0.000
2540 - 2545	0	1.000



HISTOGRAM FOR

TIME OF POP-UP MANEUVER FOR RPV 9

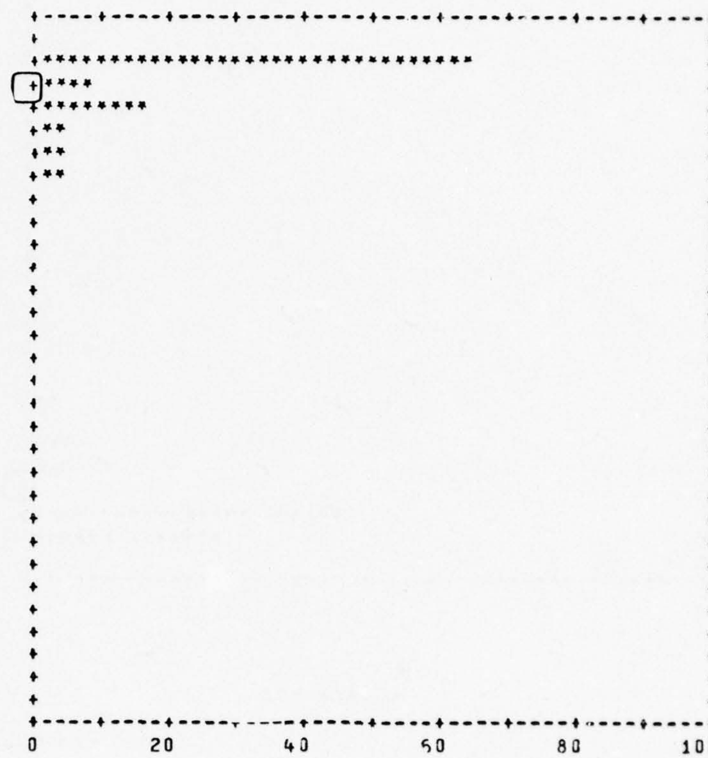
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2350 - 2355	0	0.000
2360 - 2365	7	.280
2370 - 2375	12	.480
2380 - 2385	0	0.000
2390 - 2395	3	.120
2400 - 2405	2	.080
2410 - 2415	0	0.000
2420 - 2425	1	.040
2430 - 2435	0	0.000
2440 - 2445	0	0.000
2450 - 2455	0	0.000
2460 - 2465	0	0.000
2470 - 2475	0	0.000
2480 - 2485	0	0.000
2490 - 2495	0	0.000
2500 - 2505	0	0.000
2510 - 2515	0	0.000
2520 - 2525	0	0.000
2530 - 2535	0	0.000
2540 - 2545	0	0.000
2550 - 2555	0	0.000
2560 - 2565	0	0.000
2570 - 2575	0	0.000
2580 - 2585	0	0.000
2590 - 2595	0	0.000
2600 - 2605	0	0.000
2610 - 2615	0	0.000
2620 - 2625	0	0.000
2630 - 2635	0	0.000
2640 - 2645	0	0.000



HISTOGRAM FOR

TIME OF POP-UP MANEUVER FOR RPV 10

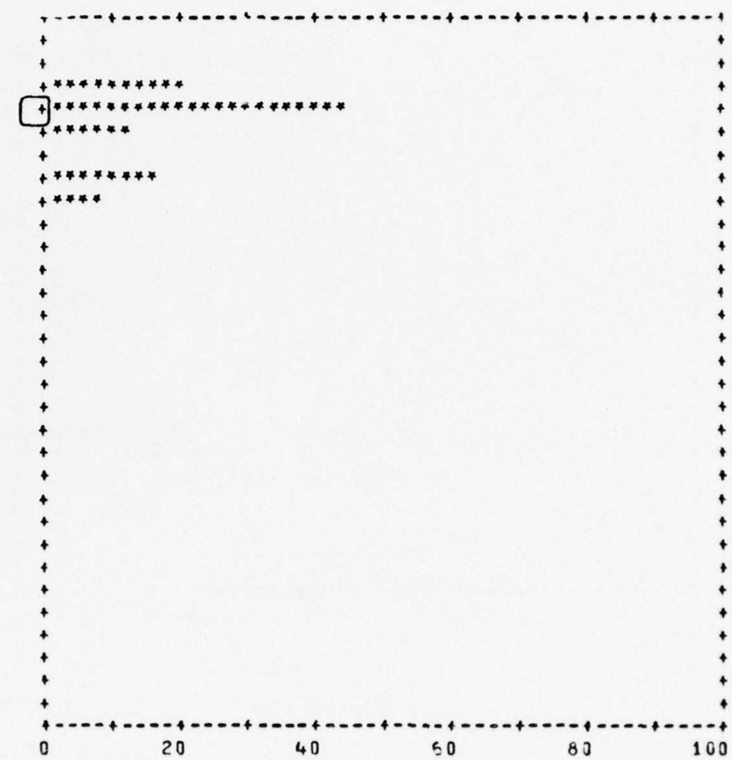
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2300 - 2305	0	0.000
2310 - 2315	16	.640
2320 - 2325	2	.080
2330 - 2335	4	.160
2340 - 2345	1	.040
2350 - 2355	1	.040
2360 - 2365	1	.040
2370 - 2375	0	0.000
2380 - 2385	0	0.000
2390 - 2395	0	0.000
2400 - 2405	0	0.000
2410 - 2415	0	0.000
2420 - 2425	0	0.000
2430 - 2435	0	0.000
2440 - 2445	0	0.000
2450 - 2455	0	0.000
2460 - 2465	0	0.000
2470 - 2475	0	0.000
2480 - 2485	0	0.000
2490 - 2495	0	0.000
2500 - 2505	0	0.000
2510 - 2515	0	0.000
2520 - 2525	0	0.000
2530 - 2535	0	0.000
2540 - 2545	0	0.000
2550 - 2555	0	0.000
2560 - 2565	0	0.000
2570 - 2575	0	0.000
2580 - 2585	0	0.000
2590 - 2595	0	0.000



HISTOGRAM FOR

TIME OF POP-UP MANEUVER FOR RPV 11

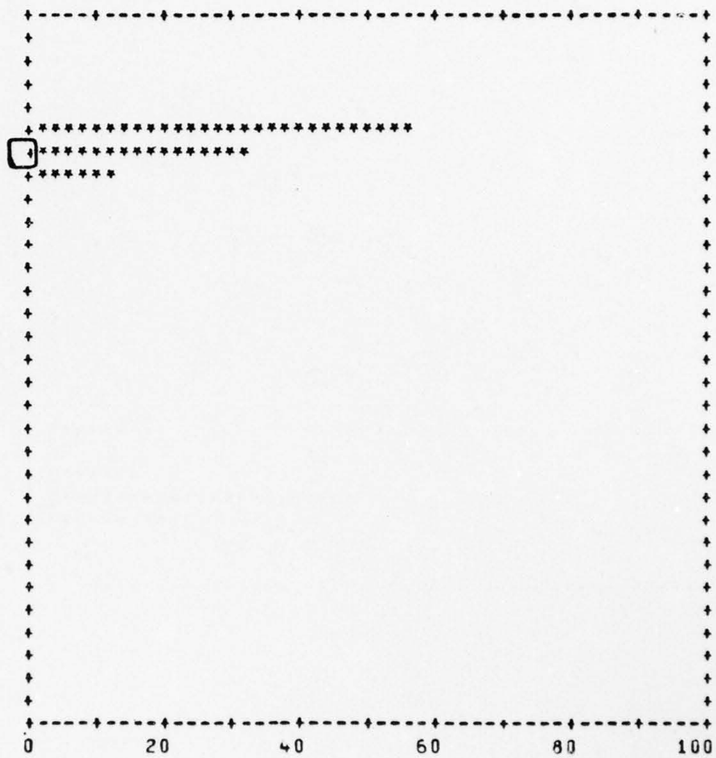
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2350 - 2355	0	0.000
2360 - 2365	0	0.000
2370 - 2375	5	.200
2380 - 2385	11	.440
2390 - 2395	3	.120
2400 - 2405	0	0.000
2410 - 2415	4	.160
2420 - 2425	2	.080
2430 - 2435	0	0.000
2440 - 2445	0	0.000
2450 - 2455	0	0.000
2460 - 2465	0	0.000
2470 - 2475	0	0.000
2480 - 2485	0	0.000
2490 - 2495	0	0.000
2500 - 2505	0	0.000
2510 - 2515	0	0.000
2520 - 2525	0	0.000
2530 - 2535	0	0.000
2540 - 2545	0	0.000
2550 - 2555	0	0.000
2560 - 2565	0	0.000
2570 - 2575	0	0.000
2580 - 2585	0	0.000
2590 - 2595	0	0.000
2600 - 2605	0	0.000
2610 - 2615	0	0.000
2620 - 2625	0	0.000
2630 - 2635	0	0.000
2640 - 2645	0	0.000



HISTOGRAM FOR

TIME OF POP-UP MANEUVER FOR RPV 12

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2450 - 2455	0	0.000
2460 - 2465	0	0.000
2470 - 2475	0	0.000
2480 - 2485	0	0.000
2490 - 2495	14	.560
2500 - 2505	8	.320
2510 - 2515	3	.120
2520 - 2525	0	0.000
2530 - 2535	0	0.000
2540 - 2545	0	0.000
2550 - 2555	0	0.000
2560 - 2565	0	0.000
2570 - 2575	0	0.000
2580 - 2585	0	0.000
2590 - 2595	0	0.000
2600 - 2605	0	0.000
2610 - 2615	0	0.000
2620 - 2625	0	0.000
2630 - 2635	0	0.000
2640 - 2645	0	0.000
2650 - 2655	0	0.000
2660 - 2665	0	0.000
2670 - 2675	0	0.000
2680 - 2685	0	0.000
2690 - 2695	0	0.000
2700 - 2705	0	0.000
2710 - 2715	0	0.000
2720 - 2725	0	0.000
2730 - 2735	0	0.000
2740 - 2745	0	0.000



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SAINT SIMULATION OF A REMOTELY PILOTED VEHICLE/DRONE CONTROL FA--ETC(U)
JUN 76 D B WORTMAN, D J SEIFERT, S D DUKET F33615-75-C-5012

UNCLASSIFIED AMRL-TR-75-118 NL

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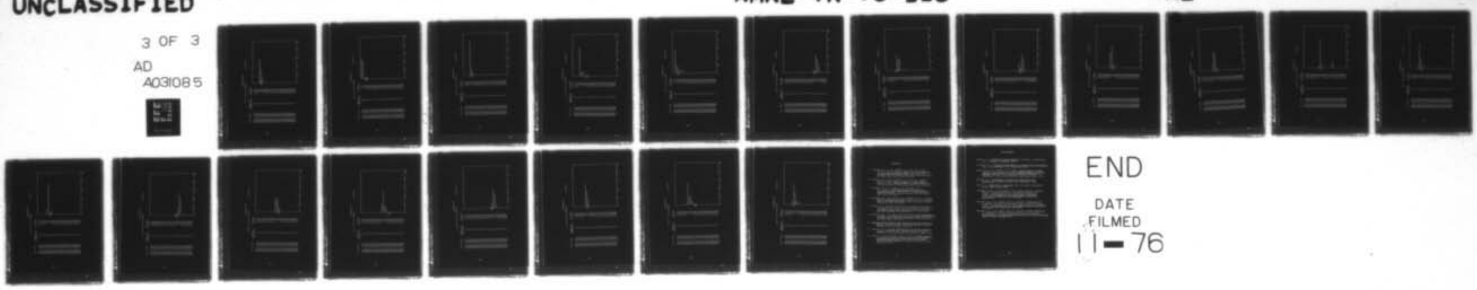

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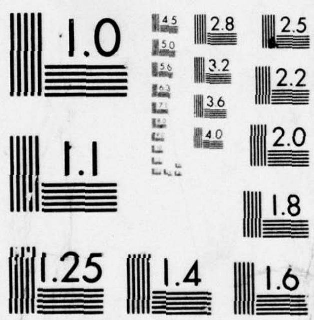
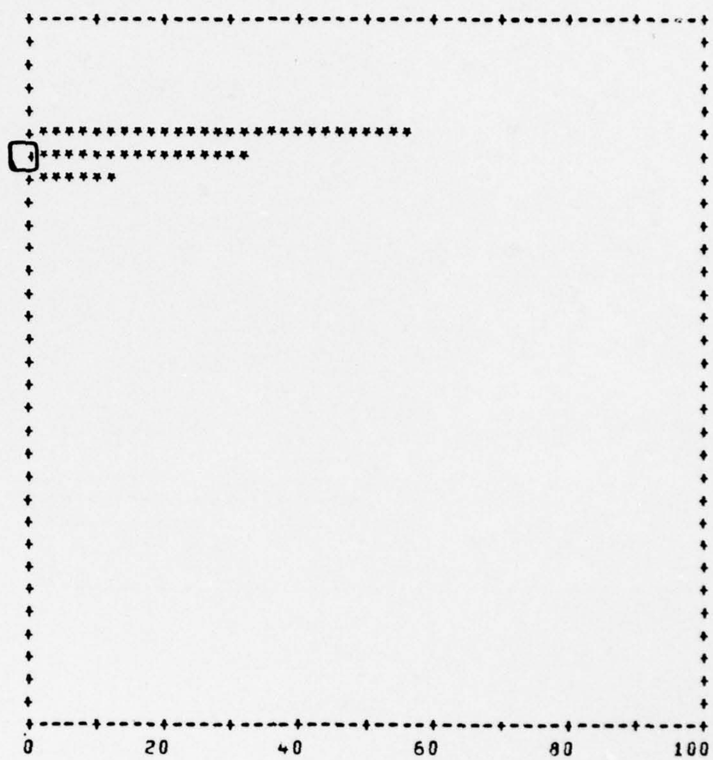


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

HISTOGRAM FOR

TIME OF POP-UP MANEUVER FOR RPV 12

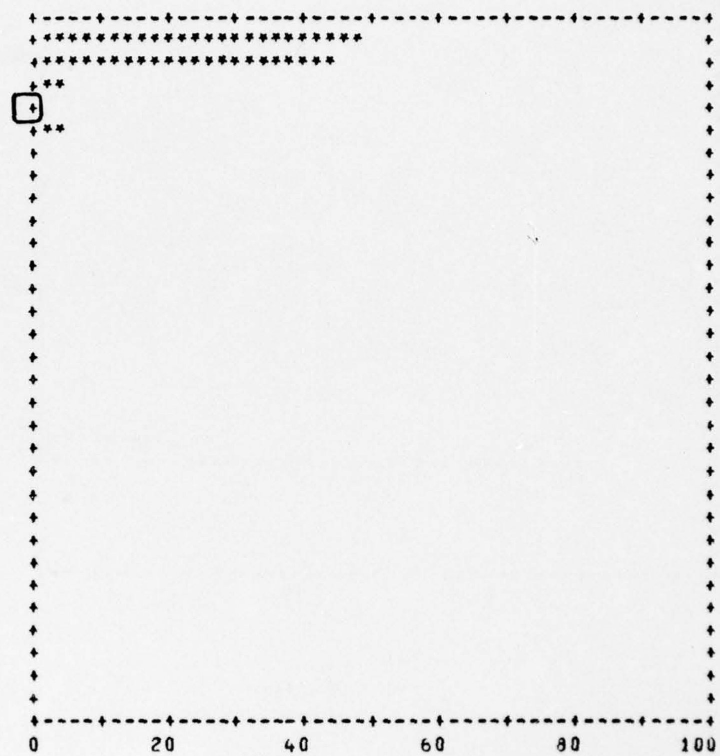
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2450 - 2455	0	0.000
2460 - 2465	0	0.000
2470 - 2475	0	0.000
2480 - 2485	0	0.000
2490 - 2495	14	.560
2500 - 2505	8	.320
2510 - 2515	3	.120
2520 - 2525	0	0.000
2530 - 2535	0	0.000
2540 - 2545	0	0.000
2550 - 2555	0	0.000
2560 - 2565	0	0.000
2570 - 2575	0	0.000
2580 - 2585	0	0.000
2590 - 2595	0	0.000
2600 - 2605	0	0.000
2610 - 2615	0	0.000
2620 - 2625	0	0.000
2630 - 2635	0	0.000
2640 - 2645	0	0.000
2650 - 2655	0	0.000
2660 - 2665	0	0.000
2670 - 2675	0	0.000
2680 - 2685	0	0.000
2690 - 2695	0	0.000
2700 - 2705	0	0.000
2710 - 2715	0	0.000
2720 - 2725	0	0.000
2730 - 2735	0	0.000
2740 - 2745	0	0.000



HISTOGRAM FOR

TIME OF POP-UP MANEUVER FOR RPV 13

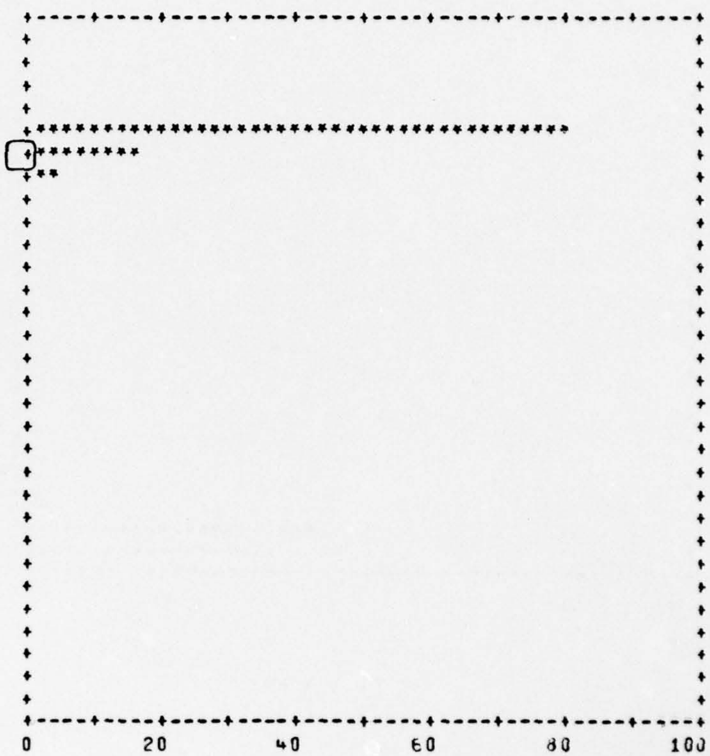
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2350 - 2355	12	.480
2360 - 2365	11	.440
2370 - 2375	1	.040
2380 - 2385	0	0.000
2390 - 2395	1	.040
2400 - 2405	0	0.000
2410 - 2415	0	0.000
2420 - 2425	0	0.000
2430 - 2435	0	0.000
2440 - 2445	0	0.000
2450 - 2455	0	0.000
2460 - 2465	0	0.000
2470 - 2475	0	0.000
2480 - 2485	0	0.000
2490 - 2495	0	0.000
2500 - 2505	0	0.000
2510 - 2515	0	0.000
2520 - 2525	0	0.000
2530 - 2535	0	0.000
2540 - 2545	0	0.000
2550 - 2555	0	0.000
2560 - 2565	0	0.000
2570 - 2575	0	0.000
2580 - 2585	0	0.000
2590 - 2595	0	0.000
2600 - 2605	0	0.000
2610 - 2615	0	0.000
2620 - 2625	0	0.000
2630 - 2635	0	0.000
2640 - 2645	0	0.000



HISTOGRAM FOR

TIME OF POP-UP MANEUVER FOR RPV 14

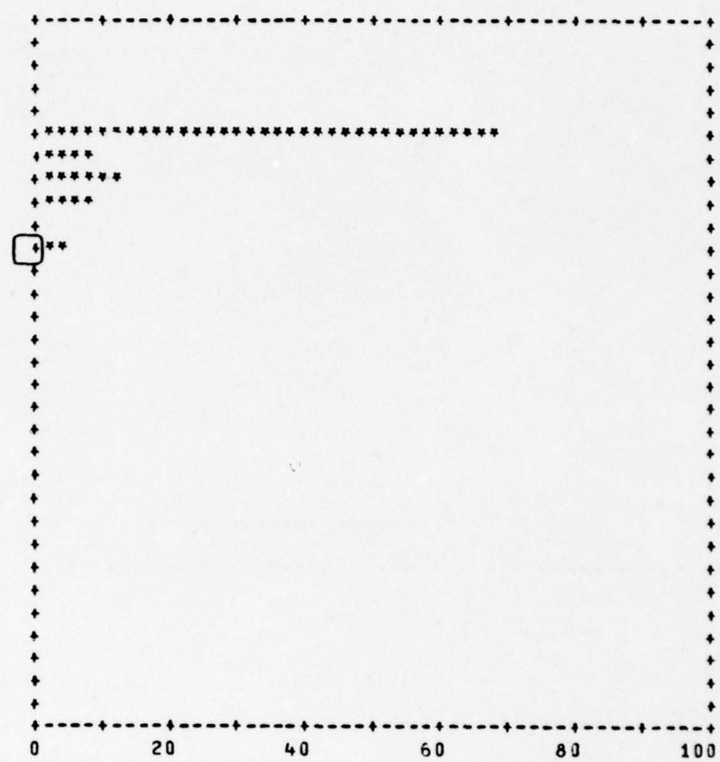
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2450 - 2455	0	0.000
2460 - 2465	0	0.000
2470 - 2475	0	0.000
2480 - 2485	0	0.000
2490 - 2495	20	.800
2500 - 2505	4	.160
2510 - 2515	1	.040
2520 - 2525	0	0.000
2530 - 2535	0	0.000
2540 - 2545	0	0.000
2550 - 2555	0	0.000
2560 - 2565	0	0.000
2570 - 2575	0	0.000
2580 - 2585	0	0.000
2590 - 2595	0	0.000
2600 - 2605	0	0.000
2610 - 2615	0	0.000
2620 - 2625	0	0.000
2630 - 2635	0	0.000
2640 - 2645	0	0.000
2650 - 2655	0	0.000
2660 - 2665	0	0.000
2670 - 2675	0	0.000
2680 - 2685	0	0.000
2690 - 2695	0	0.000
2700 - 2705	0	0.000
2710 - 2715	0	0.000
2720 - 2725	0	0.000
2730 - 2735	0	0.000
2740 - 2745	0	0.000



HISTOGRAM FOR

TIME OF POP-UP MANEUVER FOR RPV 15

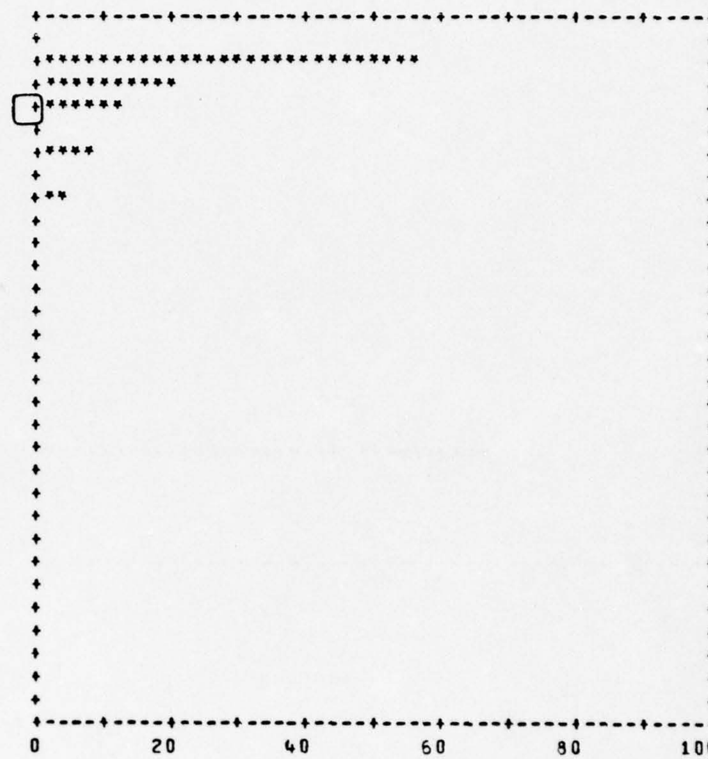
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2550 - 2555	0	0.000
2560 - 2565	0	0.000
2570 - 2575	0	0.000
2580 - 2585	0	0.000
2590 - 2595	17	.680
2600 - 2605	2	.080
2610 - 2615	3	.120
2620 - 2625	2	.080
2630 - 2635	0	0.000
2640 - 2645	1	.040
2650 - 2655	0	0.000
2660 - 2665	0	0.000
2670 - 2675	0	0.000
2680 - 2685	0	0.000
2690 - 2695	0	0.000
2700 - 2705	0	0.000
2710 - 2715	0	0.000
2720 - 2725	0	0.000
2730 - 2735	0	0.000
2740 - 2745	0	0.000
2750 - 2755	0	0.000
2760 - 2765	0	0.000
2770 - 2775	0	0.000
2780 - 2785	0	0.000
2790 - 2795	0	0.000
2800 - 2805	0	0.000
2810 - 2815	0	0.000
2820 - 2825	0	0.000
2830 - 2835	0	0.000
2840 - 2845	0	0.000



HISTOGRAM FOR

TIME OF POP-UP MANEUVER FOR RPV 16

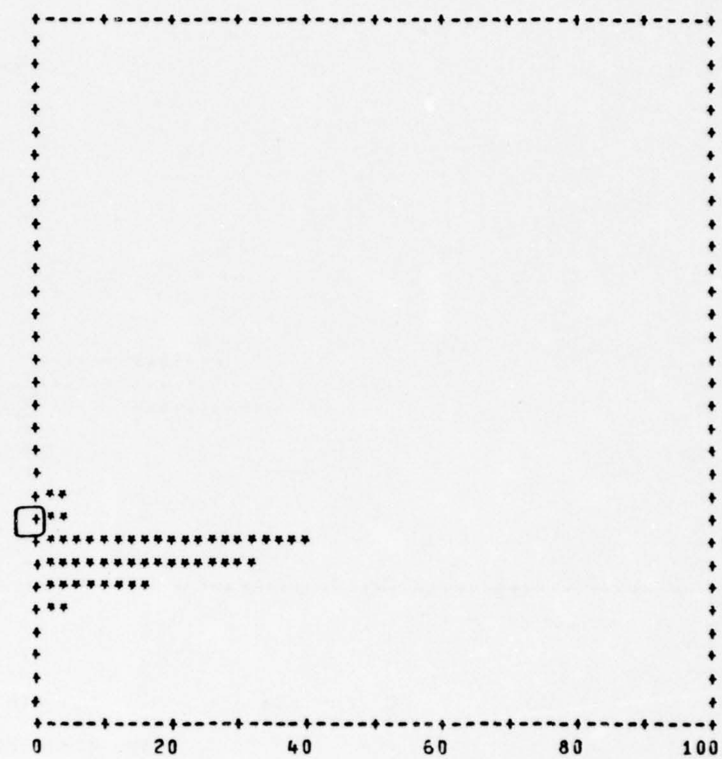
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2700 - 2705	0	0.000
2710 - 2715	14	.560
2720 - 2725	5	.200
2730 - 2735	3	.120
2740 - 2745	0	0.000
2750 - 2755	2	.080
2760 - 2765	0	0.000
2770 - 2775	1	.040
2780 - 2785	0	0.000
2790 - 2795	0	0.000
2800 - 2805	0	0.000
2810 - 2815	0	0.000
2820 - 2825	0	0.000
2830 - 2835	0	0.000
2840 - 2845	0	0.000
2850 - 2855	0	0.000
2860 - 2865	0	0.000
2870 - 2875	0	0.000
2880 - 2885	0	0.000
2890 - 2895	0	0.000
2900 - 2905	0	0.000
2910 - 2915	0	0.000
2920 - 2925	0	0.000
2930 - 2935	0	0.000
2940 - 2945	0	0.000
2950 - 2955	0	0.000
2960 - 2965	0	0.000
2970 - 2975	0	0.000
2980 - 2985	0	0.000
2990 - 2995	0	0.000



HISTOGRAM FOR

TIME OF POP-DOWN MANEUVER FOR RPV 1

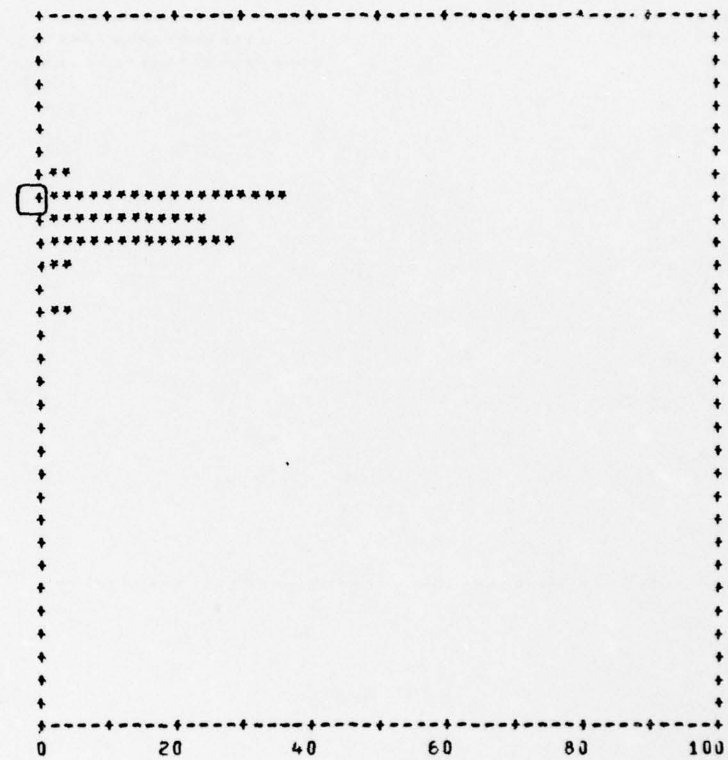
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
1750 - 1755	0	0.000
1760 - 1765	0	0.000
1770 - 1775	0	0.000
1780 - 1785	0	0.000
1790 - 1795	0	0.000
1800 - 1805	0	0.000
1810 - 1815	0	0.000
1820 - 1825	0	0.000
1830 - 1835	0	0.000
1840 - 1845	0	0.000
1850 - 1855	0	0.000
1860 - 1865	0	0.000
1870 - 1875	0	0.000
1880 - 1885	0	0.000
1890 - 1895	0	0.000
1900 - 1905	0	0.000
1910 - 1915	0	0.000
1920 - 1925	0	0.000
1930 - 1935	0	0.000
1940 - 1945	0	0.000
1950 - 1955	1	.040
1960 - 1965	1	.040
1970 - 1975	10	.400
1980 - 1985	8	.320
1990 - 1995	4	.160
2000 - 2005	1	.040
2010 - 2015	0	0.000
2020 - 2025	0	0.000
2030 - 2035	0	0.000
2040 - 2045	0	0.000



HISTOGRAM FOR

TIME OF POP-DOWN MANEUVER FOR RPV 2

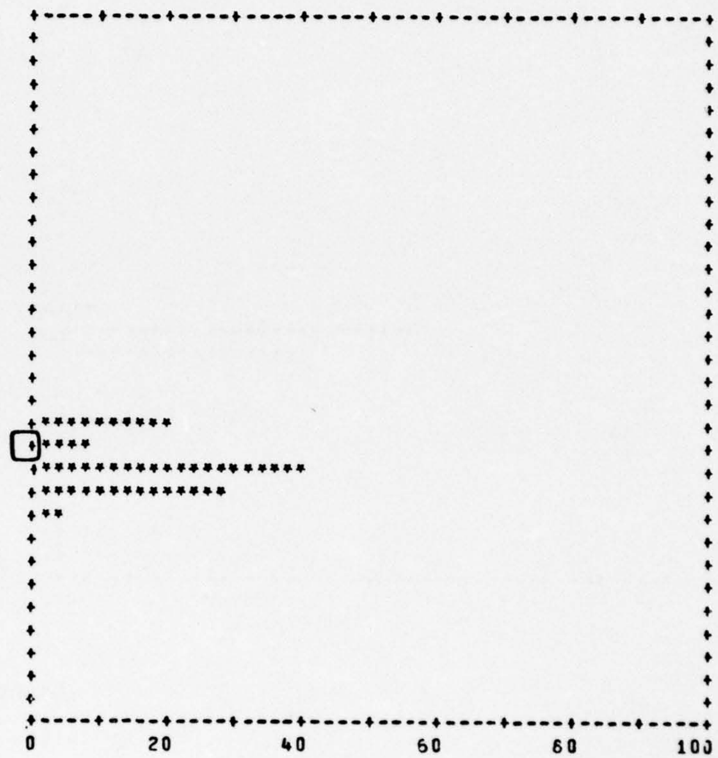
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
1900 - 1905	0	0.000
1910 - 1915	0	0.000
1920 - 1925	0	0.000
1930 - 1935	0	0.000
1940 - 1945	0	0.000
1950 - 1955	0	0.000
1960 - 1965	1	.040
1970 - 1975	9	.360
1980 - 1985	6	.240
1990 - 1995	7	.280
2000 - 2005	1	.040
2010 - 2015	0	0.000
2020 - 2025	1	.040
2030 - 2035	0	0.000
2040 - 2045	0	0.000
2050 - 2055	0	0.000
2060 - 2065	0	0.000
2070 - 2075	0	0.000
2080 - 2085	0	0.000
2090 - 2095	0	0.000
2100 - 2105	0	0.000
2110 - 2115	0	0.000
2120 - 2125	0	0.000
2130 - 2135	0	0.000
2140 - 2145	0	0.000
2150 - 2155	0	0.000
2160 - 2165	0	0.000
2170 - 2175	0	0.000
2180 - 2185	0	0.000
2190 - 2195	0	0.000



HISTOGRAM FOR

TIME OF POP-DOWN MANEUVER FOR RPV 4

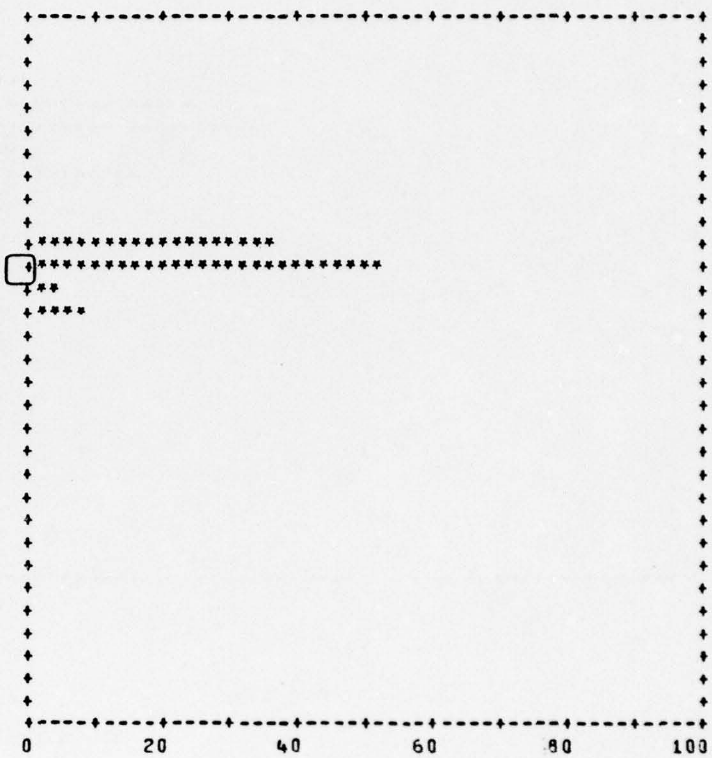
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
1850 - 1855	0	0.000
1960 - 1865	0	0.000
1870 - 1875	0	0.000
1880 - 1885	0	0.000
1890 - 1895	0	0.000
1900 - 1905	0	0.000
1910 - 1915	0	0.000
1920 - 1925	0	0.000
1930 - 1935	0	0.000
1940 - 1945	0	0.000
1950 - 1955	0	0.000
1960 - 1965	0	0.000
1970 - 1975	0	0.000
1980 - 1985	0	0.000
1990 - 1995	0	0.000
2000 - 2005	0	0.000
2010 - 2015	0	0.000
2020 - 2025	5	.200
2030 - 2035	2	.080
2040 - 2045	10	.400
2050 - 2055	7	.280
2060 - 2065	1	.040
2070 - 2075	0	0.000
2080 - 2085	0	0.000
2090 - 2095	0	0.000
2100 - 2105	0	0.000
2110 - 2115	0	0.000
2120 - 2125	0	0.000
2130 - 2135	0	0.000
2140 - 2145	0	0.000



HISTOGRAM FOR

TIME OF POP-DOWN MANEUVER FOR RPV 5

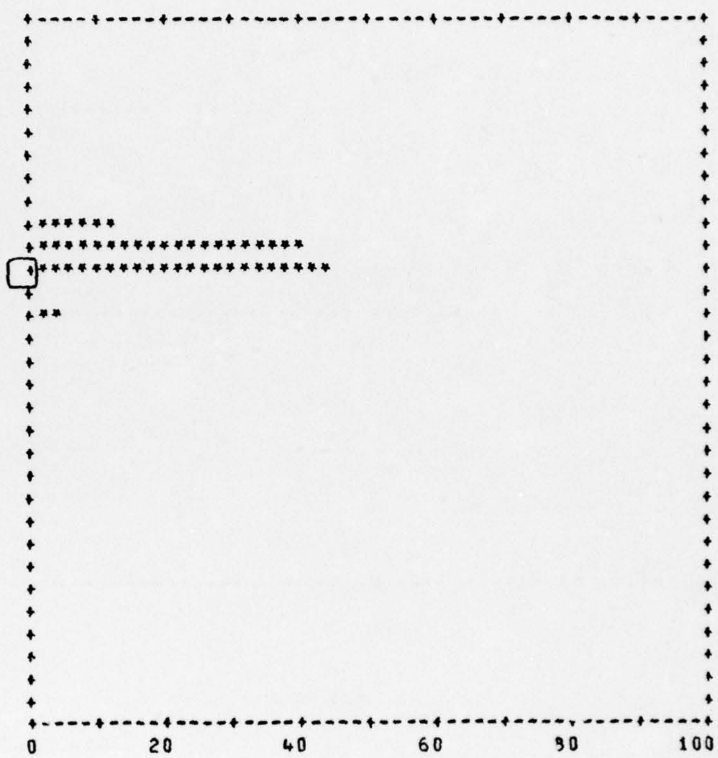
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
1950 - 1955	0	0.000
1960 - 1965	0	0.000
1970 - 1975	0	0.000
1980 - 1985	0	0.000
1990 - 1995	0	0.000
2000 - 2005	0	0.000
2010 - 2015	0	0.000
2020 - 2025	0	0.000
2030 - 2035	0	0.000
2040 - 2045	9	.360
2050 - 2055	13	.520
2060 - 2065	1	.040
2070 - 2075	2	.080
2080 - 2085	0	0.000
2090 - 2095	0	0.000
2100 - 2105	0	0.000
2110 - 2115	0	0.000
2120 - 2125	0	0.000
2130 - 2135	0	0.000
2140 - 2145	0	0.000
2150 - 2155	0	0.000
2160 - 2165	0	0.000
2170 - 2175	0	0.000
2180 - 2185	0	0.000
2190 - 2195	0	0.000
2200 - 2205	0	0.000
2210 - 2215	0	0.000
2220 - 2225	0	0.000
2230 - 2235	0	0.000
2240 - 2245	0	0.000



HISTOGRAM FOR

TIME OF POP-DOWN MANEUVER FOR RPV 6

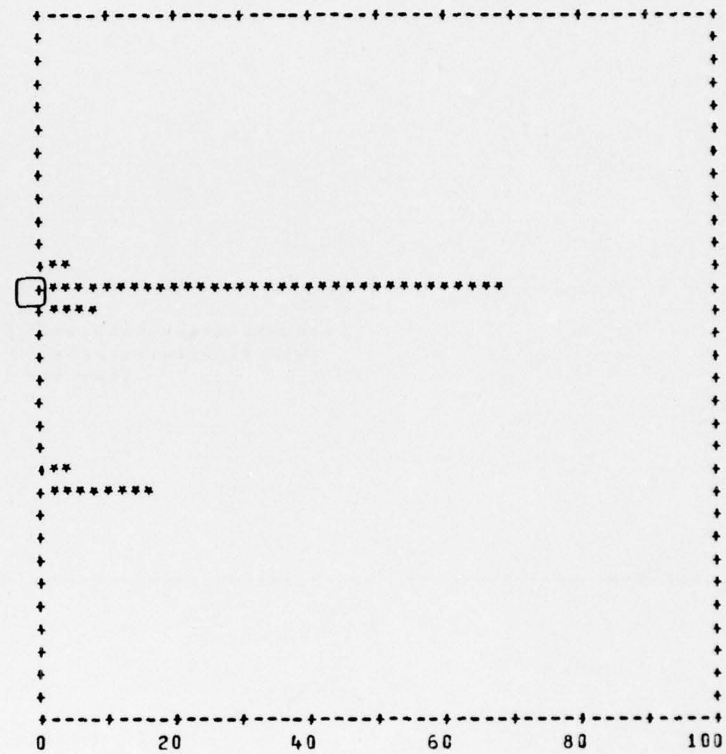
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2050 - 2055	0	0.000
2060 - 2065	0	0.000
2070 - 2075	0	0.000
2080 - 2085	0	0.000
2090 - 2095	0	0.000
2100 - 2105	0	0.000
2110 - 2115	0	0.000
2120 - 2125	0	0.000
2130 - 2135	3	.120
2140 - 2145	10	.400
2150 - 2155	11	.440
2160 - 2165	0	0.000
2170 - 2175	1	.040
2180 - 2185	0	0.000
2190 - 2195	0	0.000
2200 - 2205	0	0.000
2210 - 2215	0	0.000
2220 - 2225	0	0.000
2230 - 2235	0	0.000
2240 - 2245	0	0.000
2250 - 2255	0	0.000
2260 - 2265	0	0.000
2270 - 2275	0	0.000
2280 - 2285	0	0.000
2290 - 2295	0	0.000
2300 - 2305	0	0.000
2310 - 2315	0	0.000
2320 - 2325	0	0.000
2330 - 2335	0	0.000
2340 - 2345	0	0.000



HISTOGRAM FOR

TIME OF POP-DOWN MANEUVER FOR RPV 7

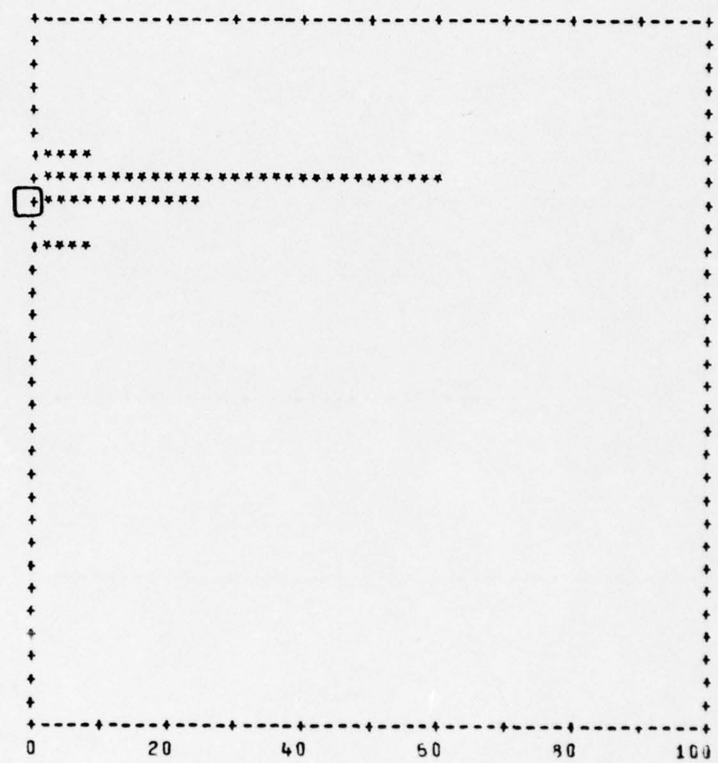
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2200 - 2205	0	0.000
2210 - 2215	0	0.000
2220 - 2225	0	0.000
2230 - 2235	0	0.000
2240 - 2245	0	0.000
2250 - 2255	0	0.000
2260 - 2265	0	0.000
2270 - 2275	0	0.000
2280 - 2285	0	0.000
2290 - 2295	0	0.000
2300 - 2305	1	.040
2310 - 2315	17	.680
2320 - 2325	2	.080
2330 - 2335	0	0.000
2340 - 2345	0	0.000
2350 - 2355	0	0.000
2360 - 2365	0	0.000
2370 - 2375	0	0.000
2380 - 2385	0	0.000
2390 - 2395	1	.040
2400 - 2405	4	.160
2410 - 2415	0	0.000
2420 - 2425	0	0.000
2430 - 2435	0	0.000
2440 - 2445	0	0.000
2450 - 2455	0	0.000
2460 - 2465	0	0.000
2470 - 2475	0	0.000
2480 - 2485	0	0.000
2490 - 2495	0	0.000



HISTOGRAM FOR

TIME OF POP-DOWN MANEUVER FOR RPV 8

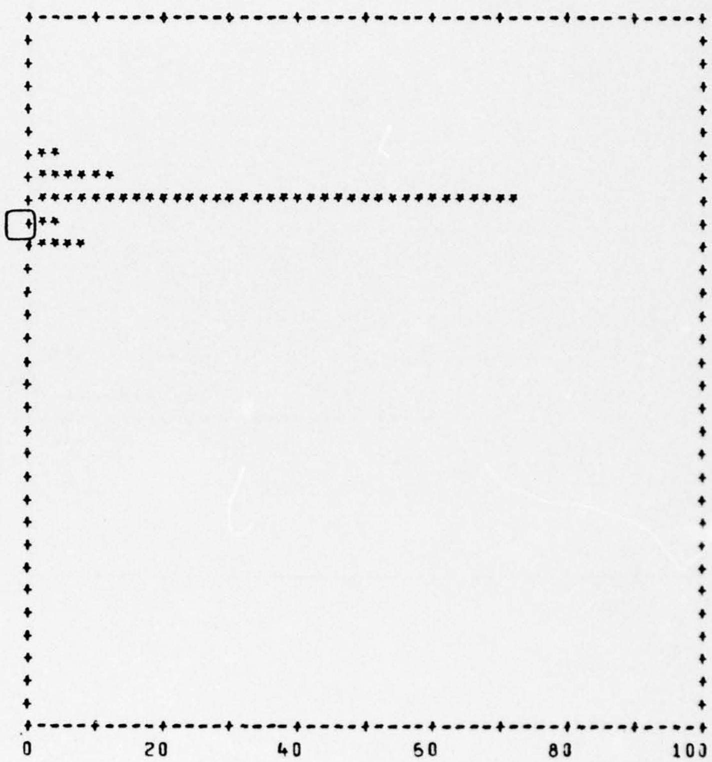
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2250 - 2255	0	0.000
2260 - 2265	0	0.000
2270 - 2275	0	0.000
2280 - 2285	0	0.000
2290 - 2295	0	0.000
2300 - 2305	2	.080
2310 - 2315	15	.600
2320 - 2325	6	.240
2330 - 2335	0	0.000
2340 - 2345	2	.080
2350 - 2355	0	0.000
2360 - 2365	0	0.000
2370 - 2375	0	0.000
2380 - 2385	0	0.000
2390 - 2395	0	0.000
2400 - 2405	0	0.000
2410 - 2415	0	0.000
2420 - 2425	0	0.000
2430 - 2435	0	0.000
2440 - 2445	0	0.000
2450 - 2455	0	0.000
2460 - 2465	0	0.000
2470 - 2475	0	0.000
2480 - 2485	0	0.000
2490 - 2495	0	0.000
2500 - 2505	0	0.000
2510 - 2515	0	0.000
2520 - 2525	0	0.000
2530 - 2535	0	0.000
2540 - 2545	0	0.000



HISTOGRAM FOR

TIME OF PUP-DOWN MANEUVER FOR RPV 9

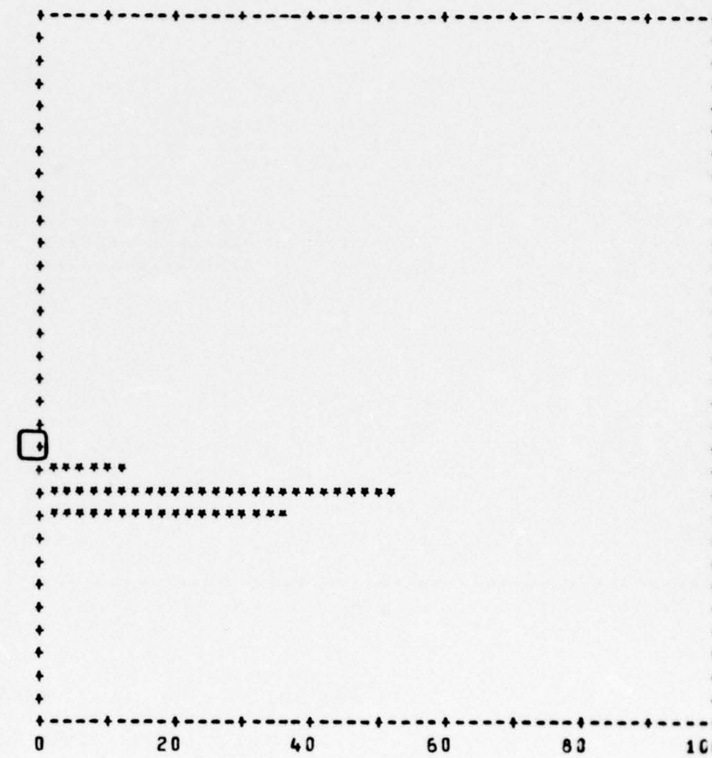
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2350 - 2355	0	0.000
2360 - 2365	0	0.000
2370 - 2375	0	0.000
2380 - 2385	0	0.000
2390 - 2395	0	0.000
2400 - 2405	1	.040
2410 - 2415	3	.120
2420 - 2425	18	.720
2430 - 2435	1	.040
2440 - 2445	2	.080
2450 - 2455	0	0.000
2460 - 2465	0	0.000
2470 - 2475	0	0.000
2480 - 2485	0	0.000
2490 - 2495	0	0.000
2500 - 2505	0	0.000
2510 - 2515	0	0.000
2520 - 2525	0	0.000
2530 - 2535	0	0.000
2540 - 2545	0	0.000
2550 - 2555	0	0.000
2560 - 2565	0	0.000
2570 - 2575	0	0.000
2580 - 2585	0	0.000
2590 - 2595	0	0.000
2600 - 2605	0	0.000
2610 - 2615	0	0.000
2620 - 2625	0	0.000
2630 - 2635	0	0.000
2640 - 2645	0	0.000



HISTOGRAM FOR

TIME OF POP-DOWN MANEUVER FOR RPV 10

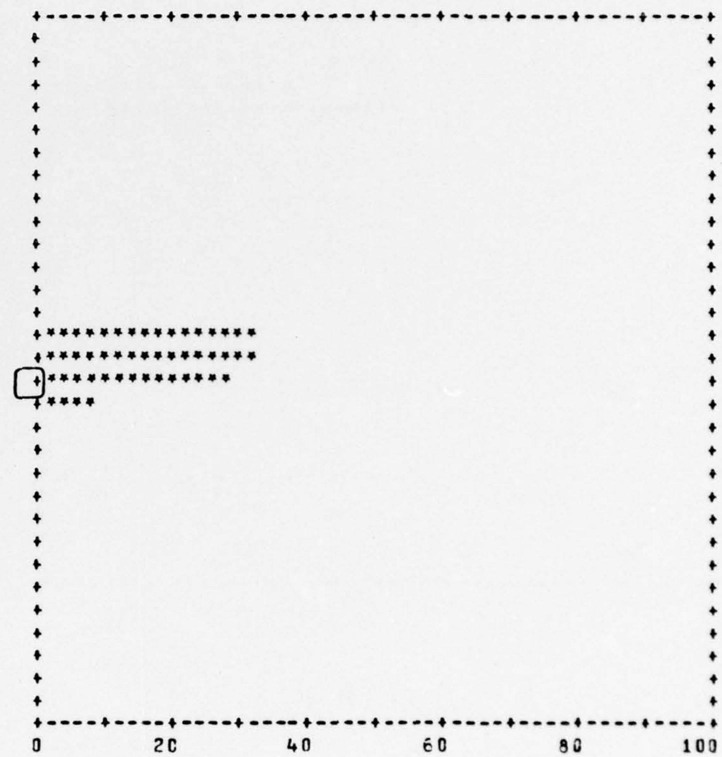
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2300 - 2305	0	0.000
2310 - 2315	0	0.000
2320 - 2325	0	0.000
2330 - 2335	0	0.000
2340 - 2345	0	0.000
2350 - 2355	0	0.000
2360 - 2365	0	0.000
2370 - 2375	0	0.000
2380 - 2385	0	0.000
2390 - 2395	0	0.000
2400 - 2405	0	0.000
2410 - 2415	0	0.000
2420 - 2425	0	0.000
2430 - 2435	0	0.000
2440 - 2445	0	0.000
2450 - 2455	0	0.000
2460 - 2465	0	0.000
2470 - 2475	0	0.000
2480 - 2485	0	0.000
2490 - 2495	3	.120
2500 - 2505	13	.520
2510 - 2515	9	.360
2520 - 2525	0	0.000
2530 - 2535	0	0.000
2540 - 2545	0	0.000
2550 - 2555	0	0.000
2560 - 2565	0	0.000
2570 - 2575	0	0.000
2580 - 2585	0	0.000
2590 - 2595	0	0.000



HISTOGRAM FOR

TIME OF POP-DOWN MANEUVER FOR RPV 11

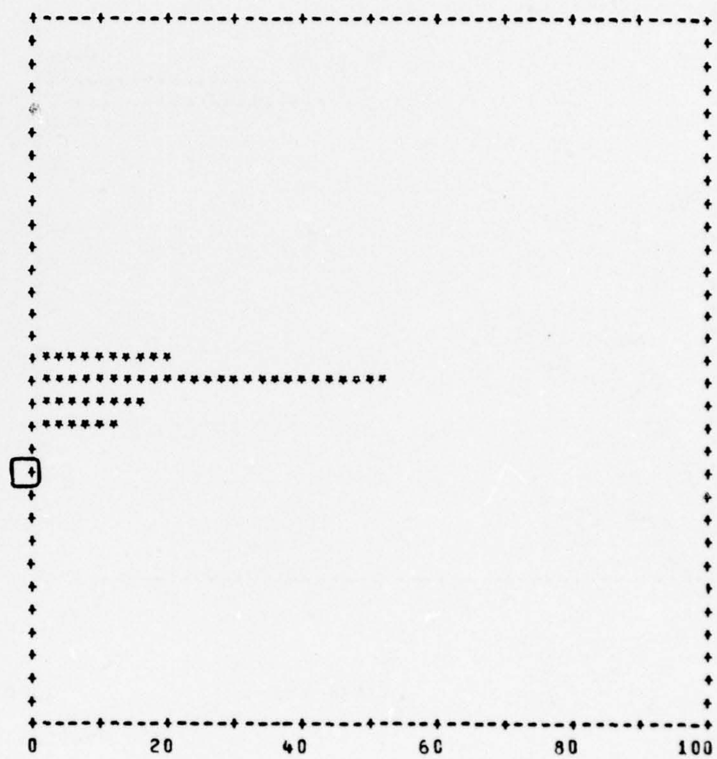
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2350 - 2355	0	0.000
2360 - 2365	0	0.000
2370 - 2375	0	0.000
2380 - 2385	0	0.000
2390 - 2395	0	0.000
2400 - 2405	0	0.000
2410 - 2415	0	0.000
2420 - 2425	0	0.000
2430 - 2435	0	0.000
2440 - 2445	0	0.000
2450 - 2455	0	0.000
2460 - 2465	0	0.000
2470 - 2475	0	0.000
2480 - 2485	8	.320
2490 - 2495	8	.320
2500 - 2505	7	.280
2510 - 2515	2	.080
2520 - 2525	0	0.000
2530 - 2535	0	0.000
2540 - 2545	0	0.000
2550 - 2555	0	0.000
2560 - 2565	0	0.000
2570 - 2575	0	0.000
2580 - 2585	0	0.000
2590 - 2595	0	0.000
2600 - 2605	0	0.000
2610 - 2615	0	0.000
2620 - 2625	0	0.000
2630 - 2635	0	0.000
2640 - 2645	0	0.000



HISTOGRAM FOR

TIME OF POP-DOWN MANEUVER FOR RPV 12

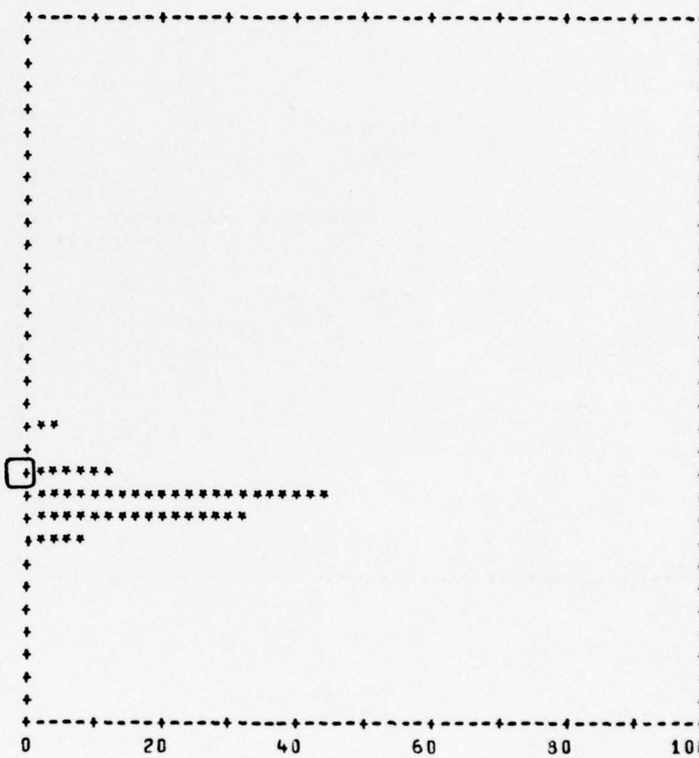
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2450 - 2455	0	0.000
2460 - 2465	0	0.000
2470 - 2475	0	0.000
2480 - 2485	0	0.000
2490 - 2495	0	0.000
2500 - 2505	0	0.000
2510 - 2515	0	0.000
2520 - 2525	0	0.000
2530 - 2535	0	0.000
2540 - 2545	0	0.000
2550 - 2555	0	0.000
2560 - 2565	0	0.000
2570 - 2575	0	0.000
2580 - 2585	0	0.000
2590 - 2595	5	.200
2600 - 2605	13	.520
2610 - 2615	4	.160
2620 - 2625	3	.120
2630 - 2635	0	0.000
2640 - 2645	0	0.000
2650 - 2655	0	0.000
2660 - 2665	0	0.000
2670 - 2675	0	0.000
2680 - 2685	0	0.000
2690 - 2695	0	0.000
2700 - 2705	0	0.000
2710 - 2715	0	0.000
2720 - 2725	0	0.000
2730 - 2735	0	0.000
2740 - 2745	0	0.000



HISTOGRAM FOR

TIME OF POP-DOWN MANEUVER FOR RPV 13

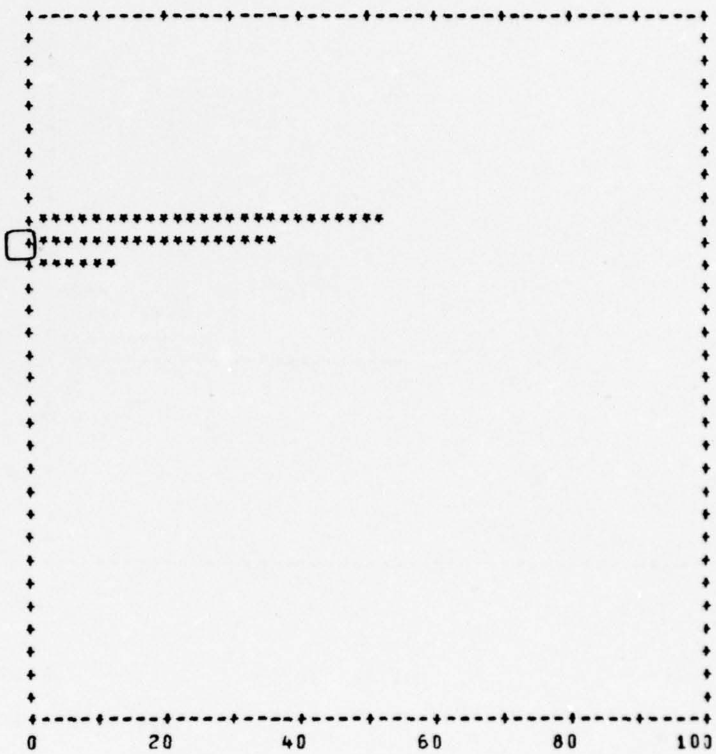
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2350 - 2355	0	0.000
2360 - 2365	0	0.000
2370 - 2375	0	0.000
2380 - 2385	0	0.000
2390 - 2395	0	0.000
2400 - 2405	0	0.000
2410 - 2415	0	0.000
2420 - 2425	0	0.000
2430 - 2435	0	0.000
2440 - 2445	0	0.000
2450 - 2455	0	0.000
2460 - 2465	0	0.000
2470 - 2475	0	0.000
2480 - 2485	0	0.000
2490 - 2495	0	0.000
2500 - 2505	0	0.000
2510 - 2515	0	0.000
2520 - 2525	1	.040
2530 - 2535	0	0.000
2540 - 2545	3	.120
2550 - 2555	11	.440
2560 - 2565	8	.320
2570 - 2575	2	.080
2580 - 2585	0	0.000
2590 - 2595	0	0.000
2600 - 2605	0	0.000
2610 - 2615	0	0.000
2620 - 2625	0	0.000
2630 - 2635	0	0.000
2640 - 2645	0	0.000



HISTOGRAM FOR

TIME OF POP-DOWN MANEUVER FOR RPV 14

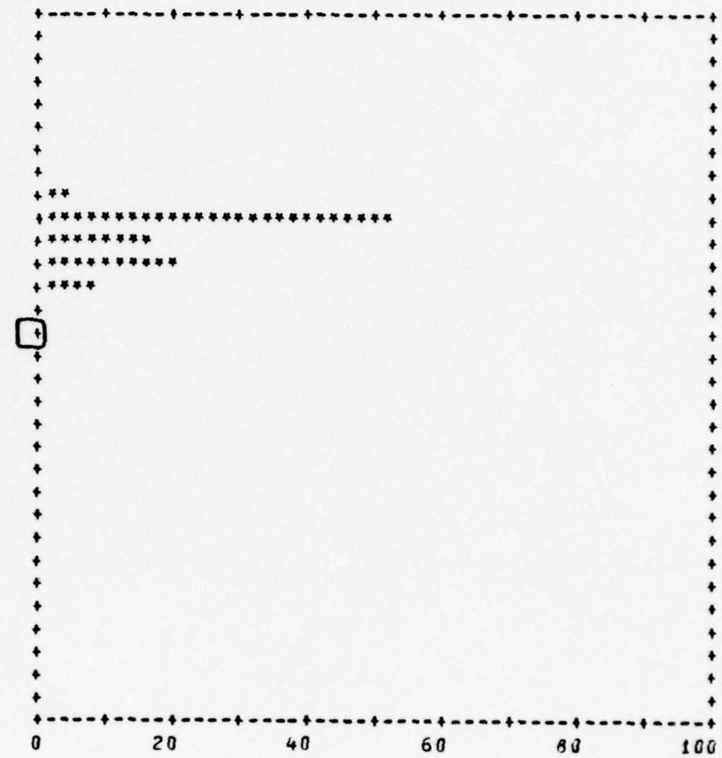
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2450 - 2455	0	0.000
2460 - 2465	0	0.000
2470 - 2475	0	0.000
2480 - 2485	0	0.000
2490 - 2495	0	0.000
2500 - 2505	0	0.000
2510 - 2515	0	0.000
2520 - 2525	0	0.000
2530 - 2535	13	.520
2540 - 2545	9	.360
2550 - 2555	3	.120
2560 - 2565	0	0.000
2570 - 2575	0	0.000
2580 - 2585	0	0.000
2590 - 2595	0	0.000
2600 - 2605	0	0.000
2610 - 2615	0	0.000
2620 - 2625	0	0.000
2630 - 2635	0	0.000
2640 - 2645	0	0.000
2650 - 2655	0	0.000
2660 - 2665	0	0.000
2670 - 2675	0	0.000
2680 - 2685	0	0.000
2690 - 2695	0	0.000
2700 - 2705	0	0.000
2710 - 2715	0	0.000
2720 - 2725	0	0.000
2730 - 2735	0	0.000
2740 - 2745	0	0.000



HISTOGRAM FOR

TIME OF POP-DOWN MANEUVER FOR RPV 15

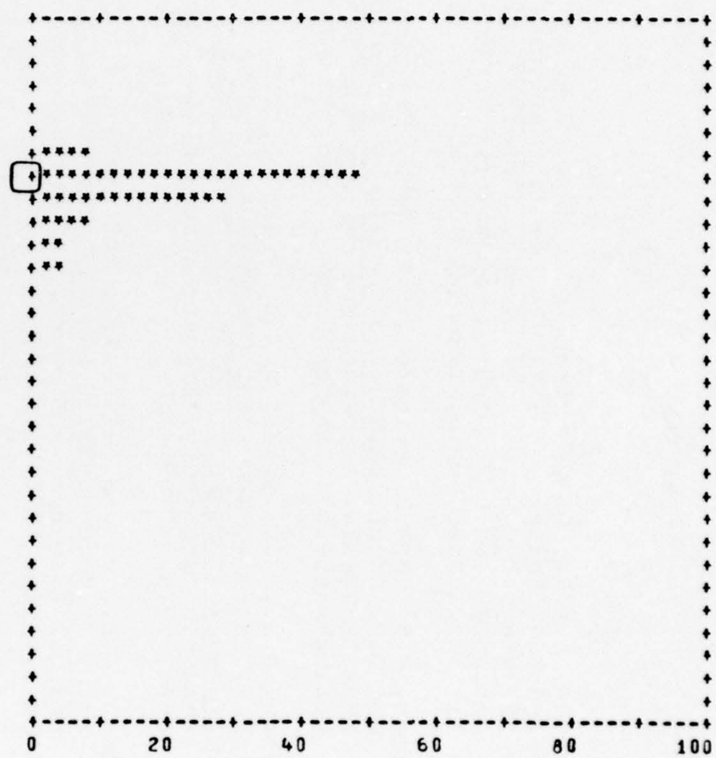
CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2550 - 2555	0	0.000
2560 - 2565	0	0.000
2570 - 2575	0	0.000
2580 - 2585	0	0.000
2590 - 2595	0	0.000
2600 - 2605	0	0.000
2610 - 2615	0	0.000
2620 - 2625	1	.040
2630 - 2635	13	.520
2640 - 2645	4	.160
2650 - 2655	5	.200
2660 - 2665	2	.080
2670 - 2675	0	0.000
2680 - 2685	0	0.000
2690 - 2695	0	0.000
2700 - 2705	0	0.000
2710 - 2715	0	0.000
2720 - 2725	0	0.000
2730 - 2735	0	0.000
2740 - 2745	0	0.000
2750 - 2755	0	0.000
2760 - 2765	0	0.000
2770 - 2775	0	0.000
2780 - 2785	0	0.000
2790 - 2795	0	0.000
2800 - 2805	0	0.000
2810 - 2815	0	0.000
2820 - 2825	0	0.000
2830 - 2835	0	0.000
2840 - 2845	0	0.000



HISTOGRAM FOR

TIME OF POP-DOWN MANEUVER FOR RPV 16

CELL LIMITS	NUMBER OF OBSERVATIONS	RELATIVE FREQUENCY
2700 - 2705	0	0.000
2710 - 2715	0	0.000
2720 - 2725	0	0.000
2730 - 2735	0	0.000
2740 - 2745	0	0.000
2750 - 2755	2	.080
2760 - 2765	12	.480
2770 - 2775	7	.280
2780 - 2785	2	.080
2790 - 2795	1	.040
2800 - 2805	1	.040
2810 - 2815	0	0.000
2820 - 2825	0	0.000
2330 - 2835	0	0.000
2840 - 2845	0	0.000
2850 - 2855	0	0.000
2860 - 2865	0	0.000
2870 - 2875	0	0.000
2880 - 2885	0	0.000
2890 - 2895	0	0.000
2900 - 2905	0	0.000
2910 - 2915	0	0.000
2920 - 2925	0	0.000
2930 - 2935	0	0.000
2940 - 2945	0	0.000
2950 - 2955	0	0.000
2960 - 2965	0	0.000
2970 - 2975	0	0.000
2980 - 2985	0	0.000
2990 - 2995	0	0.000



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